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Royal Horse Artillery.

At this eventful epoch, when Europe is convulsed in anticipation of inevitable struggles between contending Armies a brief account of some portions of the British force engaged in the contest may prove acceptable to the reader.

Originally the French pre-eminently excelled in this arm, and derived incalculable advantage by its application over the Austrians.—In 1802 their "flying, or Horse Artillery" consisted of eight-pounders and six-inch Howitzers. The ammunition was carried in light caissons, and most of the men were mounted, while the remainder rode on the "wursts." By this arrangement, in addition to the acknowledged abilities of the French cannoniers, the Republican Horse Artillery acquired a far-famed celebrity and deserved reputation. The British Horse Brigade was first formed by the Duke of Richmond in January 1793. This addition to the Royal Artillery consisted of two Troops, with a Lieutenant Colonel, and in the following year two more were added, with a Colonel, en seconde, and a Major. A further increase of one Lieutenant Colonel, and two troops was made in 1794, and in 1799 the Subalterns were all selected from the First Lieutenants. In 1801 a Colonel Commandant, a Lieutenant Colonel, and one more troop were appointed, and in 1804 another Field Officer, with a Troop, were placed on the establishment.

In the following year the Brigade was further augmented by four troops, and in 1814 two rocket troops, under a Lieutenant Colonel, were likewise added. At the latter date the total strength of Officers in the Horse Artillery amounted to 81. Subsequent to the peace four troops and one rocket troop were reduced, and in 1819 two more were disbanded, leaving seven, including one rocket troop as at present. Very recently both troops and companies in the Royal Artillery have been made up to the original war establishment, but the Corps at large is greatly inferior in numerical strength to what it mustered in 1814. We had then fourteen troops and ten Battalions of ten companies each, together with four

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companies of Foreign Artillery; making a total of 104 companies. At the peace in 1814 we had twelve troops of drivers, about 610 men in each, comprising a force of 7320. This most efficient establishment, ready for any service, either with Waggons or guns, was entirely swept away in conformity with ill-advised outcry for retrenchment; no matter at what ulterior cost the sacrifice was made, On a cursory view, we are at present with a decrease of seven troops of Horse Artillery and the Corps of drivers, the latter equal to twelve Battalions. During the late war the general total of Artillery exceeded 30,000 men.

The Royal Horse Artillery now consists of seven Troops. Of these two are in Turkey, one at Woolwich, one at Weedon, one at Christchurch, one at Canterbury, and one in Dublin. Those employed in the East have each five Officers, fifteen non-commissioned officers, and 183 men, with 192 horses. All are armed with four 6 pounders, and two twelve pound Howitzers, and a rocket carriage. On service each carries nine ammunition waggons, one store limber waggon, one store cart, one store waggon, one spare gun carriage, and a forge cart. On home service they have six ammunition waggons only. Altogether each troop abroad has twenty carriages, while those at home have but sixteen. In addition to the foregoing force enumerated, it is requisite to have a reserve both of men and horses, so that a Troop or company may be expanded or contracted, according to the nature of the service on which it is employed, either in the Field or the Colonies.

At the Battle of Waterloo the English Horse Artillery numbered eight troops, having in all 15 nine pounders, 20 light six pounders, and 13 five and a half inch howitzers. Total number of pieces, 48. The whole strength of British, King's German Legion, and Hanoverian Artillery present, including 18 guns and 1 howitzer in reserve, amounted to 132 pieces of ordnance.*

* Naval and Millitary Gazette, 23rd September 1854

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THE WAR IN THE CRIMEA.

Siege of Sebastopol.

The annexed Memorandum has been published for the information of the Army in the Crimea.

Memorandum.

Camp before Sebastopol,
28th November, 1854.

At ordinary sieges, and in proportion as a fortress is small, and on old systems of construction, the fire of besiegers dispersed, tirailleurs may be very effective.

The system can never be so influential before a place like Sebastopol, on account of its size, the force of the Garrison, the extensive front presented in every direction, and the rocky nature of the soil; still many great advantages may be obtained by the judicious employment of Riflemen.

Some spirited efforts have been made at times, by different parties, under Officers who have taken an interest in this kind of service; but in general its principle does not seem to have been attended to in our service, and the application of it is reported to be very irregular in the trenches, and frequently neglected altogether when it might be most useful, partly on account of its nature and effective power not being thoroughly understood—one very common mistake made being, that when a smart fire of Artillery is opened upon the Riflemen, the fire ought to be discontinued, whereas, *in general,* it should be the more persevered in.

A few principles on this service are here submitted, and it is recommended that special bodies should be organized for it in each Division, under the persuasion that the Generals in command of them would find the arrangement very generally useful, even independently of the duty in the trenches, where, however, a portion should be always on duty and actively engaged.

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It is an ordinary proceeding at sieges to employ select bodies of marksmen against the Artillerymen of the Garrison. With the old musket they posted themselves at different distances, not unusually exceeding 200 yards from the enemy's batteries, and their effect was such as very commonly absolutely to silence the guns immediately opposed to them.

With rifles, and the modern Minié in the hands of good shots, the effect may be produced at much greater ranges.

The French applied these means of annoyance universally and with system; the men should be selected for being good shots, energetic, and spirited, and Volunteers; they should have Officers of the same qualifications (though not necessarily good shots) and of intelligence; the service when well executed is to be entitled to great credit.

In order to protect the trenches from the effects of the fire of the Garrison, and to close with the Artillery as early as possible, it is a practice to establish parties of such Riflemen in different order, in distinct pits, sunk at night, 50 or 100 yards in front of the besiegers' works, where usually two men in each pit remain all day, under cover of the earth excavated and some sand-bag loop holes, firing at every favorable moment.

They have no covered communication with the trenches, but as individuals, run occasionally across to and fro, without much loss,

The pits may be from 5 to 10 or 20 yards asunder, and with practised men the service is continued actively and effectually *in spite of any opposition.* When the Artillery in front open fire upon them, it is a sure sign that it is suffering from the fire, and encourages the parties to encreased exertion, and the contest usually ends in the early superiority of the musketry.

Dispersed as these men are, and well covered, the direct fire of shot, shell, or grape, has little real effect on them, while their fire on the gunners is very destructive. Any pe-

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riod of heavy convergent fire, from different directions on small portions, may render it proper that they should keep close till the storm is over, but always in readiness to resume their work as opportunities offer.

These men are supplied with larger quantities of ammunition than others, although the consumption will not always be very great, as it is by steady aim and attention to the practice, rather than by quick indiscriminate firing, the greatest effects are produced.

The continuous trench is far more favorable to this service, when it can be obtained, than detached pits; the parties have more freedom of action, can support one another, and the whole being lined with sand-bag loop holes, the enemy never knowing where the men are, nor from whence to expect the shot.

The longer ranges, for which the rifles and Miniés are serviceable, renders this more practicable; the value of this particular service will be greatly enhanced by the superior expertness of the soldier as marksmen.

(Signed) J. F. BURGOYNE,

United Service Gazette, December 30th, 1854.

Experiments to ascertain the effects of Shot in and upon iron Ships.—Extracted from a Treatise on Naval Gunnery, by Lieutenant General Sir H. DOUGLAS, *Bart. G. C. B.; G. C. M. and G.; F. R. S.*

In the present year, 1851, some experiments, of which notice is given below, were carried on at Portsmouth under the direction of Captain Chads, C. B., R. N., in order to try the effects of shot in and upon iron ships. These are to be considered as an extension of the courses of experiments mentioned in the body of this work. *

* Vide Artillery Records, "Miscellaneous" from page 250 to page 255.

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A distinct knowledge of all the facts
trials is a matter of such immense impc
thor thinks it necessary to present to th
of all the experiments that have been m
actly the effects of shot of various desc
ribs of iron.

The first experiment, made on the 6
was for the purpose of testing the resis
against musketry, canister, and grape sl
was also fired at, to make a comparison b
terials. A marine's percussion musket
$4\frac{1}{2}$ drs.; distance, 40 yards.

Iron plates, $\frac{1}{8}$ Oak plank, 1 inch	All passed th
Iron plates, $\frac{2}{8}$ Oak plank, 2 inch	4 in 6 passed
Iron plates, $\frac{3}{8}$ Oak plank, 3 inch	Both musket

Canister, 100 yards: 6 lbs. cl

Iron plates, $\frac{3}{8}$ Oak plank, 3 inch,	Passed through.
Iron plates, $\frac{4}{8}$ Oak plank, 4 inch,	Canister proof.

Grape, 200 yards: 6 lbs. charge.

Iron plates, $\frac{4}{8}$ " " $\frac{5}{8}$ " " $\frac{6}{8}$	All passed through.
Oak plank, 4 inch, " " 5 inch,	All passed through.
" " 6 inch,	Generally passed through.

Experiments were made in June, 1850, against two sections cf the Simoom, $\frac{5}{8}$ inch thick, placed 35 feet apart: the guns and charges were those used in all steam-vessels.

The result was, that two or three shot, or sometimes even a single one striking near the water-line of an iron vessel, must endanger the ship.

Another most serious evil is, that the shot breaks, on striking, into innumerable pieces, which pass into the ship with such force as to range afterwards to a distance of 400 or

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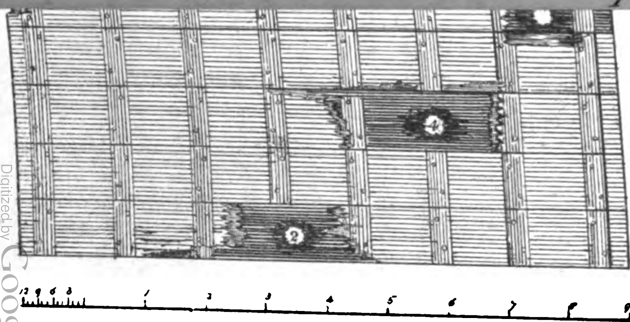

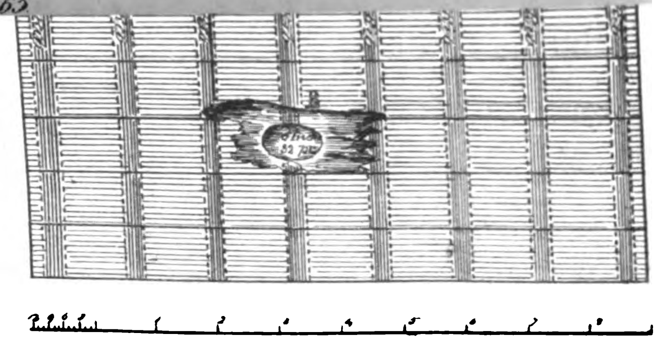

Madras Artillery Depôt

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500 yards, and that the effect on men at their quarters would be more destructive than canister shot, supposing them to pass through a ship's side, as when the plates are only $\frac{5}{8}$ inch thick.

Experiments were made on the 11th July, 1850* against an iron section similar to the Simoom; it was filled in and made solid, with $5\frac{1}{2}$ inch oak timber between the iron ribs, and $4\frac{1}{2}$ inch oak planking above the waterways, which were 1 foot thick, and with 3 inch fir above the port sills; these were strongly secured to the iron plates by bolts.

The results were as follow:—

The holes made by the shot were not so irregular as on the former occasion, but as clear and open. All parts of the shot passed right through the iron and timber, and then split and spread abroad with considerable velocity; parts of the iron plates, and a few very small pieces of shot, were sometimes retained in the timber.

With low charges the shot did not split into so many pieces as before.

With high charges the splinters from the shot were as numerous and as severe as before, with the addition, in this and the former case, of the evil to which other vessels are subject—that of the splinters torn from the timbers.

On the 13th August, 1850, an iron section similar to the Simoom was prepared with a covering of fir plank on the outside, of the thickness of 2, 3, and 4 inches in different parts.

The result of this experiment was similar to the last, when the wood was on the inside, with the exception of the splinters from the wood.

The holes made by the shot were regular, of the full size of the shot, and open.

Every shot split on passing through; those between the ribs into a few pieces only; those that struck on the ribs into

* Vide Artillery Records, "Miscellaneous" from page 250 to page 253.

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a great number; in both cases, when combined with the splinters of the iron side, the effect must prove highly destructive.

A comparison as to the effect of shot on iron and timber was made by firing 8 inch hollow shot, and 32 lb. solid shot, at a butt built for experimental shell-firing, with timber having 6 inch plank on the outside, and 4 inch within; the result was, that the splinters from the wood were trifling when compared with those from the iron.

Experiments were made on the 10th October, 1850, against an iron section similar to the Simoom, lined on the inside with a composition called by Mr. Walters, the inventor, kamptulicon; the result was the same as the former trials when lined with wood. It neither prevented the shot from breaking into numerous small pieces, nor did the hole close up, as was anticipated, after the shot had passed through.

Experiments were made on the 5th July, 1851, at a butt constructed with oak and fir uprights, to represent the timbers of a ship; one half covered with $\frac{3}{8}$ths, and the other half with $\frac{4}{8}$ths sheet-iron.

The first practice was with the iron outside (Fig. 1, Plate 15*): *32* lb. solid shot, and 8-inch hollow shot, with distant charges, passed through the $\frac{3}{8}$ths iron without splitting.

In firing against the $\frac{4}{8}$ths iron plates, two of the shot, on striking a double part where there was a joint, split into four or five pieces, but not in the destructive manner as on the former occasion against the $\frac{5}{8}$ths plates.

Some shot that passed through this part were picked up and found to be starred or cracked, showing that $\frac{4}{8}$ths is the extreme thickness of iron which should be employed in constructing iron vessels, in order to prevent the breaking of the shot.

The shot on passing through the $\frac{4}{8}$ plate iron made clear,

* It has not been thought necessary to describe, in detail, the fractures and ravages made by the shot. The delineations, faithfully reported, *sautent aux yeux*, and carry conviction to the mind.

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clean holes, of their own diameters, without rending the iron further, but the disc struck out was invariably broken into numerous pieces. Fig. 2 represents the reverse of the target, and exhibits the effects on the timbers.

The butt was subsequently turned, so as to represent the off-side (Fig. 2, Plate 15), where the shot would strike the timbers before passing through the iron: reduced charges were used to diminish the velocity of the shot to what it would be after having passed through the front side.

A 32-pounder shot passed through an oak timber, carrying away the iron at the back in a fearful manner, laying open a space of 19 inches by 12, and curling the iron up so as to preclude the possibility of stopping it if under water.

An 8-inch shot also struck a fir timber, with almost a similar result; the hole was 2 feet 6 inches by 10 inches.

Experiments of the 11th and 12th of August, 1851.

The particular objects of these experiments were to endeavour to diminish or obviate the destructive effects produced as above on iron plates by the impacts of shot, and to prevent the shot from splitting into pieces. For these purposes a butt was constructed to represent a section of the Simoom, formed of iron ribs of $\frac{5}{8}$ inch iron, $4\frac{1}{2}$ inches wide, and $11\frac{1}{2}$ inches apart, instead of iron plates: these were covered with 5-inch teak planking on the outside and 2-inch on the inside (Figs. 3 and 4 Plate 15). The breadth of the 5-inch planking was $10\frac{1}{4}$ inches, and of the 2-inch, $9\frac{5}{8}$ inches.

This butt, 10 feet long by 8 in depth, was fixed between piles firmly driven at the distance of 450 yards from the guns, and with the outside face towards them.

No. 1, Solid shot, 32-pounder, 56 cwt. gun, 10 pound charge.—Hit direct about 3 feet from the centre of the butt, making an open hole (1, Fig. 3) the size of the shot with a jagged edge through the 5-inch teak; it then cut directly through an iron rib, carrying away 7 inches of it; the shot then, with the pieces of the rib, passed through the 2-inch

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teak close to the edge of a plank, carrying away an extent of 3 feet in length by 1½ in height.

A large number of splinters both of wood and iron were found; the iron ones ranging from 200 to 400 yards: the shot passed on to 1300 or 1400 yards.

No. 2, Solid shot, 32-pounder, 56 cwt. gun, 10 pounds charge.—Hit direct 9 inches from the bottom (Fig. 3), and about the middle part of the butt, making an open hole the size of the shot with a jagged edge, through the 5-inch teak; it then cut through the back of an iron rib, carrying away 10 inches of the lower part of it; the shot then, with the pieces of the rib, passed through the 2-inch teak in the centre of a plank, carrying away an extent of 3 feet in length by 1 in height, which probably would have been greater but that the shot struck so near the bottom of the butt and centre of a plank.

A large number of splinters both of wood and iron were produced; the iron ones ranging from 200 to 400 yards: the shot passed on to 1500 or 1600 yards.

No. 3, Hollow shot, 56 lbs., 8-inch, 65 cwt. gun, 10 pounds charge.—Hit from ricochet 25 yards short, about 2 feet from the side and 3 from the top of the butt, making an open hole the size of the shot with a jagged edge through the 5-inch teak; it then cut directly through an iron rib, carrying away 26 inches of it; the shot then with the pieces of the rib passed through the 2-inch teak at the edge of a plank, carrying away an extent of 3 feet in length by about 2 feet in height.

A large number of splinters both of wood and iron; the iron ones ranging from 200 to 400 yards; the shot passed on to 1300 or 1400 yards.

No. 4, Hollow shot, 56 lbs., 8 inch 65 cwt. gun, 10 pounds charge.—Hit direct, about 3 feet from the centre ef the butt, making an open hole the size of the shot with a jagged edge through the 5-inch teak; it then cut directly through an iron rib, carrying away 8 inches of it; the shot then with the

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pieces of the rib passed through the 2-inch teak, in the centre of a plank, carrying away an extent of 3 feet in length by 1 in height.

A large number of splinters both of wood and iron; the iron ones ranging from 200 to 400 yards; the shot passed on to 1400 or 1500 yards.

August 12th, 1851, *Experiment continued.*—A butt of the same description reversed was then used, to try the effect of shot passing off the opposite side of a ship fitted in this manner.

For this purpose 5 lbs. charges were used with the 8-inch and 4 lbs. with the 32-pounder gun, to allow for the decreased velocity of the shot after having passed through the first side with a 10-pounds charge.

With solid shot, 32-pounder, 56 cwt., 4-pounds charge.—Hit direct 2 feet from the bottom and about the middle part of the butt (B, Fig. 4, Plate 15), making an open hole the size of the shot with a jagged edge through the 2-inch teak; it then cut directly through an iron rib, carrying away about 7 inches of it; the shot then with the pieces of the rib passed through the 5-inch teak near the edge of a plank, making an open hole 12 inches in length by 6 in height, but the wood much splintered to 3 feet in length by 14 inches in height.

A great number of wooden splinters, but not many iron ones observed; the shot passed on to 700 yards.

Hollow shot, 56 lbs., 8 inch 65 cwt. gun, 5-pounds charge. —Hit direct, at A, Fig. 4. plate 15, about 2 feet from the top, in the centre of the butt, making an open hole the size of the shot with a jagged edge through the 2-inch teak; it then cut through the back of an iron rib, carrying away about 18 inches of the upper part of it; the shot then, with the pieces of the rib, passed through the 5-inch teak in the centre of a plank, making an open hole 12 inches long by 9

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inches wide, but the wood much splintered to 3 feet in length by 1 foot in height, and the next plank above half broken through in the centre.

A great number of wooden splinters and some iron, ranged from 100 to 200 yards; the shot passed on to 900 yards.

The holes these two shots made on passing out, it would have been almost impossible to have stopped.

Thus, it appears that the destructive effects of the impacts of shot on iron cannot be prevented. If the iron sides are of the thickness required to give adequate strength to the ship ($\frac{5}{8}$, or at least $\frac{4}{8}$ of an inch), the shot will be broken by the impact; if the iron plates be thin enough to let the shct pass into the ship without breaking, the vessel will be deficient in strength; the shot will do its work, particularly in oblique or raking fire, more effectively than its splinters, and in passing out, make apertures more difficult to plug or stop than in passing in. When a clean hole is made by a shot penetrating an iron plate, the whole of the disc strnck out by the shot, is broken into numerous small pieces, which are driven into the ship with very destructive effects; and if the plate be so thick (viz. upwards of $\frac{4}{8}$ of an inch) as to cause the shot to break on striking, the fragments will nevertheless pass into the ship, as in the case of a concussion or percussion horizontal shell and so produce a terrific compound effect by the fragments of both. The author has now before him a heap of the specimens of both, consisting of small, ragged, deadly splinters, varying in weight from two or three ounces to as many pounds, which he picked up in experiments he witnessed. Better to have a neat, clean hole made in one's body, than to be lacerated by the cruel and, in most cases, incurable wounds produced by splinters detached from iron sides. The expedient of combining wood and iron, either by substituting timber for the iron ribs, or the reverse—outside planking for the iron plates—makes the matter worse. The pieces

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of ribs struck off, sometimes of great length, pass on with the shot, to produce more extensive ravages elsewhere.*

From what has been stated† and shown in this Article, it cannot be denied that iron vessels, however convenient and advantageous in other respects, are utterly unfit for purposes of war; and this being indisputably so, it becomes a question of serious import to decide whether iron steamers which have been condemned as ships of war, on account of the extensive ravages produced by the impacts and penetrations of shot, upon and in vessels formed of that material, are fit to be employed as transports for the conveyance of troops and stores in the event of war.

Having several of these vessels on hand, the Admiralty have acted wisely in employing them as troop-ships at present. Four have accordingly been appointed to, and fitted for, that important service. The armaments have been removed from the main-decks, and a few light guns placed on the upper-decks, where timber is substituted for iron in the

* Descriptions of some of the Splinters of Iron Plates, Rivets, and Shot, picked up in the space between the Targets set up to represent a section of an iron vessel. The splinters were taken promiscuously from innumerable fragments found there when the firing ceased.

Description.	Greatest Dimension.	Least Dimension.	Weight.
	Inches.	Inches.	Ounces.
Splinter of a plate, extremely jagged and pointed, ...	1½	⅛	¾
Splinter of a plate near a rivet, bent, jagged, and pointed, ...	2	⅛	1
Splinter of a plate near a rivet, . .	1⅝	⅛	1¼
Piece of a rivet, a good deal flattened, bent, and jagged, ...	1¾	⅛	1¾
Splinter of a shot much jagged, . .	1¾	⅛	2¼
Splinter of a plate extremely jagged and pointed, ...	2	⅛	2⅝
Splinter of a plate, with part of a rivet attached, of very irregular shape, pointed and jagged in all parts, ...	2¼	Too irregular to be defined.	3¼
Splinter of a shot, very jagged and two of the edges sharp, ...	1¾	Ditto	3½
The larger specimens varied from 3½, 4½, and 6 ounces, to nearly as many pounds; all of them were extremely jagged, pointed, and, in some cases, sharp at the edges, .			

† Vide pages 248 to 255 "Miscellaneous," Artillery Records.

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formation of their bulwarks; this removes some of the objections to iron-sides, inasmuch as the men fighting the guns on those decks, would not be liable to suffer more from an enemy's shot than in a wooden ship.

There can be no doubt of the advantages and expediency of employing those vessels as troop-ships in time of peace. Their safety from conflagration; their speed with steam power; the advantages of the screw, which admits of such vessels having great sailing power, and, on the whole, their great capacities and capabilities of voyaging, which have been so well exemplified in their performances, prove that the best possible use is being made of those vessels by so employing them during peace. But, in war, it is not enough that the people on the upper-decks will not be exposed to the destructive effects produced by shot on iron, by the substitution of timber for that material, in the upper works; for the main-decks appropriated to the troops will still be liable to the terrific effects described and delineated as above; and although, by the happy expedient of water-tight compartments, the vessel, however desperately damaged, may be prevented from sinking and the troops from being drowned, the latter cannot be protected from being killed and wounded in great numbers, or captured, in the event of falling in with, and being attacked by, any enemy's vessel armed with even a very few heavy guns.

The French were the first to propose the introduction, or use of iron, in the formation of steam vessels armed with "*la nouvelle arme*," the canon-obusier. Colonel Paixhans entertained an opinion that such vessels might thus be made shot-proof, and accordingly propounded this in his original work (Nouvelle Force Maritime, page 7), in which it is announced that the steam vessels so armed and fitted, were to be made proof against artillery by being *cuirassés en fer!* This proposition was taken into consideration by the Comité Consultatif de la Marine, to which the whole of his project was

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referred, for a report; and seriously entertained and discussed by them (see section No. 19,* pp. 92 *et seq.*, in the work just quoted); and this it was, that led to the construction of iron steamers in our naval service.

The preposterous proposition of rendering ships impenetrable to shot in this or any other manner, was found to be impracticable by any means or material available in a ship. The French soon afterwards came to the conclusion that of all vessels that can be constructed, those made of iron are the most improper for war, and they have long since desisted from any attempt to introduce iron vessels into their naval service. We must do the like, or we may suffer for it. No more such ships should be constructed.

How far iron ships are fit and safe as packets, in times of war, is another question, which will have to be well considered. The Government packets are, by their contracts, to be so built and fitted, that they may, in the event of hostilities, be converted into vessels of war: if so, it is clearly demonstrated by the facts established in these most important proofs, that vessels subject to these stipulations must not be made of iron; for of this we are sure, that iron vessels are, and will be found, unfit for all purposes of war. Whilst, therefore, the best and the most is being made of our existing iron ships, employed as they now are, we should be prepared with other means to carry on that most important service in war. We have noble ships, which have whole decks available for the reception of troops, great space for the stowage of stores—vast steam ships, possessing full steam, full sailing, and full gunnery powers, admirably adapted to these services, highly capable of executing them quickly, safely, and easily; prepared for any contingency, whether to fight or run, and therefore best suited to carry out that grand maxim—that promptitude, celerity, strength, and certainty

* Question d'avoir des vaisseaux cuirassés à l'épreuve de l'artillerie et des vaisseaux construits en fer.—pp. 92 to 95.

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in the modes and means of communication, either to succour and support our remote possessions, or to defend the centre of the empire, is, in fact, a practical multiplication of the forces of the State.

Bored-up Guns.—Extracted from a Treatise on Naval Gunnery, by Lieutenant General Sir H. DOUGLAS, *Bart. G. C. B; G. C. M. and G.; F. R. S.*

The practice of *reaming-out* guns, or boring them up, first took place in the British service in the year 1830, when about 800 guns, 24-pounders, 7 feet 6 inches long, which had been made according to the construction recommended by Sir William Congreve, and about as many more guns, also 24-pounders, of Sir Thomas Blomefield's construction, were bored up to 32-pounders for the navy.* The practice was afterwards extended to iron guns of all natures, from the 9-pounder to the 32-pounder inclusive, by enlarging the bore of each to the next, and, in some cases, to the second higher calibre, and leaving reduced windages.† This may be considered as a temporary expedient to increase the weight of metal projected from such guns as were then on hand in this country, at a time when the advantages of large calibred ordnance were not absolutely decided on, and when the Government was not prepared to sanction the expense of casting new guns for projecting the heavier natures of shot or shells. But now that the vast advantages of heavy shot are well understood, and that France, the United States, and other countries having determined on arming their ships with new, long and powerful ordnance, the time is come in which the half measure, as it may be called, should be abandoned; that the bored-up guns in the service, with such exceptions as will be mentioned presently, should be superseded, and

* Vide Table, page 125 "Miscellaneous," Artillery Records.

† The French, on the recommendation of General Paixhans, had previously decided to bore-up their long guns to the next greatest calibre: but all guns so treated have been superseded in their naval service by new guns and canons-obusiers.

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that good and efficient guns should be provided of calibres equal to those to which the bored-up guns were enlarged. By such a measure only can it be expected that in a future war our ships should be able to contend successfully with those of nations which have adopted in their navies the most approved natures of ordnance.

The great advantage arising from the reduction in the windage, together with the increase in the weight of metal projected, procured immediately for the bored-up guns a certain degree of consideration, which, it is to be apprehended, has caused the imperfections arising from the diminution of the quantity of metal in the gun itself to be overlooked. The reduced windage indeed permits, in some respects, equal effects to be produced with lower charges of powder than were used with the original gun. For instance: the old 24-pounder gun, whose windage was .211, when bored up to a 32-pounder, with a windage equal to .123, and charged with 7½ lbs. of powder, would, with rather higher elevations, propel its shot as far as the gun in its original state with its usual charge of 8 lbs. The initial velocities would be the same (about 1600 feet per second), and the force with which the shot would penetrate into any material would be, at all practicable distances, in favour of the bored-up gun. Again, if the latter were charged with 6½ lbs. of powder by which an initial velocity equal to 1490 feet per second would be produced, it would be found that the force of penetration is at first greatest in the original 24-pounder gun, with the charge of 8 lbs.; at the distance of about 400 yards from the object the penetrating forces become equal; and at all greater distances, the penetrating force of the larger shot of the bored-up gun is the greatest*

* It is to be regretted that, when the old guns were bored up to a higher calibre, measures were not taken to introduce uniformity in the quantity of windage, and that great anomalies in this respect were allowed to subsist. Thus the diameter of the bore of the old 32-pounder weighing 56 cwt., and of those weighing from 48 to 50 cwt., is 6.41 inches, while Congreve's and Blomefield's 24-pounders of 39, 40, and 41 cwt. were bored up (as 32-pounders) to 6.35 inches; and again, Blomefield's 24-pounder of 32 cwt. and his 18-pounder of 25 cwt. were

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It is not, however, from a comparison of the effects produced by the bored-up guns with those produced by the gun in its original state, that the relative values of the former, and of a gun equal in calibre but of more perfect construction, are to be determined. The advantages with respect to the power of penetration, which appear to be so much in favour of the bored-up gun, are perhaps more than counterbalanced by the defect arising from the diminution of the weight of metal in the gun, by which its recoil is rendered considerably greater than that of a gun of equal calibre and of the original formation. This circumstance, besides producting greater strain on the carriage, renders the gun more unsteady, and the practice, in consequence, more uncertain. If, in order to diminish the recoil, smaller charges of powder be employed, the penetrating power of the shot will be diminished in a corresponding degree.

Captain Simmons, in his "*Discussion on the Present Armament of the Navy*," has calculated a Table (page 18), in which are shown the relative penetrating powers of a 24-pounder gun, and the same gun reamed out to a 32-pounder, when the charge of the latter is diminished so far that the initial velocities are proportional to the weights of the guns with their carriages, when consequently the recoils or strains are rendered equal to one another. In this state the penetrating force of the bored-up gun falls even below that of the original 24-pounder, till the distance of the shot from the gun is about 3000 yards; but at such a distance as this, the elevation of the gun being necessarily high, the practice must be extremely uncertain. It is thus of the utmost importance, as well with respect to the extent and accuracy of the range as to the penetrating power of the shot, that a gun should contain a certain mass of metal with relation to the weight of

bored up(as 32-pounders, to 6·3 inches. The calibre of Mr. Monk's gun (A) is 6.375 inches Thus there have been introduced in the service four different diameters of bores for 32-pounder guns, consequently four different windages for shot of equal diameters.

† Vide Table page 125 "Miscellaneous," Artillery Records.

the projectile; a deficiency in that mass causing the advantages of a diminished windage to be in a great measure lost; the shaking of the piece before the projectile quits it, particularly when high charges of powder are used, unavoidably producing irregularity in the initial direction of the shot. The perfection of a gun consists in an union of both qualities, steadiness and the least possible windage; for only by these combined can it be rendered capable of throwing shot to the greatest distance within battle range, with the least elevation, and, consequently, with the greatest amount of useful effect.

Since the country now possesses a considerable number of new guns of large calibre and improved constructions, no reason exists for retaining bored-up guns as part of the armament of the British navy, except, perhaps, for brigs and other small vessels, or for private ships hired into the service. The French have no bored-up guns on the broadsides of their ships of the line or frigates;* nor are there any bored-up guns in the United States' navy, except the 8-inch guns, which were bored-up from 42-pounders. All the guns retained in that service are either the most efficient of the old ordnance, or certain others whose use has not yet been discontinued.† A great prejudice exists in the United States against the practice of boring-up, since a 42-pounder bored-up to a 64-pounder, the diameter being enlarged from 7 to 8

* The French ships are armed, or are appointed to be armed, with the following natures of gun, exclusive of canons-obusiers (the weights and dimensions are expressed in English denominations):—36-pounders (Fr.), length 9 ft. 7 in., and weight 69 cwt., the weight of the shot being 43.21 lbs.; 30-pounders (Fr.), No. 1, length 9 ft. 3 in., and weight 59 cwt.; 30-pounders (Fr.), No. 2, length 8 ft. 6 in., and weight 49 cwt., the weight of the shot for both being 34 lbs.; and 24-pounders (Fr.), length 9 ft. 4 in., and weight 41½ cwt., the weight of the shot being 26 lbs. 10 oz. To these have lately been added a new 50-pounder (Fr.) gun, length 10 ft. 2 in., and weight 81 cwt.; and it appears by the proceedings of the commission of Gavre, 1848, that three other new pieces of ordnance have been adopted in the French naval service. 1st. A canon-obusier (No. 3.) of 80 (*livres*); its charge for hollow-shot being 2.5 kil.=5 lbs. 8 oz., and for solid shot 2.6 kil.=5 lbs. 12 oz.: these are somewhat shorter than the pieces of the same nature already established. 2nd. A new 30-pounder (Fr.) gun (No. 3), its charge, with solid shot, being 3 kil.=6 lbs. 10 oz. (reduced charge 2.5 kil.=5 lbs. 8 oz.), and for hollow-shot, 2 kil.=4 lbs. 6.6 oz. The commission ascertained the ranges of a new 60-pounder gun, with solid shot and charges of one-third of the shot's weight: they also compared together the effects produced by this gun, the new 50-pounder and the new 30-pounder guns, with respect to range, and to the ravages made by their shot in targets representing the sides of ships.

† These are long 24-pounders, length 9 ft. 4½ in., and weight 50 cwt., and 18-pounders, length 8 ft. and weight 38 cwt., on board of the Constellation, Macedonian, and other Ships.—*Ward*, p. 36. It is perhaps to be regretted that the long 24-pounder (length 9 ft. 6 in., and weight 50 cwt.) should have been discarded from the British navy.

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inches, with a charge of 14 lbs., burst on board the Fulton, the service charge being 8 lbs.

The long 42-pounder so reamed out, and carrying a ball of 64 lbs., is said to afford, with a charge of 12 lbs., a better range at the second graze than the gun in its original state (Ward, *United States' Navy*, p. 105); but at the first graze, and at elevations not exceeding 3 degrees, the long 42-pounder with a charge of 12 lbs., which the reamed-out gun could not sustain, is greatly superior to the other.

The defects of bored-up guns were sensibly experienced on board the Sesostris steam-ship, Captain Ormsby commander. This vessel was armed with 32-pounder guns, which had been bored-up from 24-pounders; and it was found that, after a few hours' firing, the breechings were destroyed, and the bolts drawn so that her ordnance became unserviceable, even with greatly reduced charges.

Bored-up guns, besides being subject to the defect just mentioned, are found to be not altogether safe when fired with two shot; there are even some of them for which double-shotting was always prohibited; and, where the practice was allowed, very reduced charges were considered indispensable. The following Table shows the charges with single shot for bored-up guns. No charges for double shot are now officially given.*

Nature of Gun.		Proof Charge in Pounds, single Shot.	Service Charge in Pounds, single Shot.	Shot.	Wad.
	cwt.				
32-pounder	39 and 40	12	6	1	1
	32	10	5	1	1
	25	9	4	1	1
18-pounder	22	7	3	1	1
	20	7	3	1	1
	15	5	2	1	1

All the bored-up guns, with single shot, have been proved with charges equal to about one-third of the shot's weight;

* It is no longer contemplated to use double shot with any nature of bored-up guns.

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but it has been found that, after being bored-up, many of the old 24-pounders with two shot, when fired with a charge of 11 lbs. of powder, burst, after having stood, with a single shot, a charge of 18 lbs. In order that such guns may be considered safe when double-shotted, it is evident that they should be tried, so shotted, with quantities of powder considerably greater than the reduced charges stated in the Table. This uncertainty respecting the safety of the bored -up guns is surely a strong argument against them; and though it would be much better if all were discarded, it is satisfactory to find that the only bored-up guns which are now to be retained in the Royal Navy are the 32-pounders of 41 cwt., 40 cwt., and 39 cwt., which have been so converted from Blomefield's and Congreve's 24-pounders; and 18-pounders, which have been bored up from 9 and 12-pounders for the armament of small vessels. The 32-pounders just mentioned are ultimately to be replaced by the 32-pounder new gun, 8 feet long, and weighing 42 cwt.

On increasing the calibre of Field Batteries.

Much has lately been written on the necessity of increasing the calibre of our field-batteries to enable them to cope with their Russian opponents. The following is an important letter on this subject addressed to the *Times*:—

Camp before Sebastopol, December 30.

SIR,—Letters and articles having lately appeared in your columns advocating a change in the equipment of our field artillery, it is quite possible that the public may insist on a new field train being despatched to the seat-of-war without having attained requisite information on the subject. Allow me to direct the attention of your readers to some essential points of the question.

Guns of position hold an intermediate place between field and siege artillery. They cannot be manœuvred with the celerity of the former; nor are they, like the latter, disqualified by their weight from accompanying an army on the march, on practical roads. The guns of position sent to the Crimea were 18-pounders and light 32-pounders, of iron, and 8-inch howitzers and 32-pounder howitzers, of brass. When we disembarked, our deficient means of transport obliging us to leave ambulances, tents, and most of the baggage in the ships, would not admit of the guns of position accompanying the army. At the Alma, therefore, our 9-pounder batteries were opposed to the guns of position of the Russians.

Before the battle of Inkermann, our guns of position had been in part landed, and all those on shore, with the exception of the two 18-pounders used with such excellent effect by Lieutenant-Colonel Dickson, were already posted in the field-works constructed for the defence of Balaklava.

The considerations which determine the calibre of field artillery are the weight of the piece, its range, and the number of rounds that can be carried with it. Six-pounders weight 6 cwt., and carry in limber and waggon 194 rounds, but the effective range is limited to about 1,000 yards. Nine pounders weigh 13 cwt., carry 128 rounds, and range with accuracy 1,300 yards; 12-pounders weigh 18 cwt., carry 104 rounds, and their range is the same as that of 9-pounders.

Putting any gun of greater calibre than a 12-pounder out of the question, as incapable, from its weight, of being moved from point to point of a battle-field, of joining in a pursuit, or of remaining to cover a retreat, without the certainty of being sacrificed, the 9-pounders evidently combine the three requisites of lightness, range, and number of rounds in a greater degree than the others, and would drive both sixes and twelves from the field.

The French, before sending out their field-train, had their guns bored-up from 9-pounders to 12-pounders, thus in-

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creasing their calibre and slightly diminishing the weight. The consequence of this is, first, a reduction of the charge, because the recoil increasing as the weight of the piece is diminished in proportion to the weight of the shot, the trail would be split by the shock of the full charge; as the charge is diminished the elevation of the gun must be increased, rendering the aim less certain and the angle of ricochet greater, and fewer rounds are carried with the gun. Now, a 9-pounder shot is, against troops in the field, equally destructive with the 12-pounder. The only advantage attained by increasing the calibre is that of firing a shell half an inch larger in diameter, and containing (the shrapnels) 63 bullets instead of 41,—an advantage by no means compensating for the diminution in the range and number of rounds.

If we were to fight a battle with the Russians with our guns of position now with the army matched against theirs, I think our superiority would be evident at once, and I have no doubt our field artillery would, gun for gun, overpower that of the Russians at all ranges.

Your correspondent states that the Russians brought 32-pounders into the field. These were not 32-pounder guns, but 32-pounder howitzers—by no means a match for 18-pounder guns in range, aim, or, indeed, in anything but lightness and the size of their shell, which would give them a superiority in firing at masses of troops, but would never enable them to compete, gun for gun, with the 18-pounders.

The projectiles fired at the Alma from the Russian batteries were measured: the solid shot were of 16 lbs.; the shells were fired from 32-pounder howitzers. A specimen of each of the pieces firing these was taken, and may now be seen in England.

I do not by any means intend these remarks as exhaustive of the subject, or entirely disposing of the erroneous statements so frequently presented to the public with regard to artillery, but merely wish to direct attention to some essen-

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tial points, evidently not generally understood, and thus, perhaps, to induce the advocates of measures of plausible advantage to submit them to more deliberate inquiry.*

I am, Sir, your obedient servant,

(Signed.) EDWARD BRUCE HAMLEY, Capt. R.A.

On the result of firing a piece of Ordnance with a high shot sticking in the bore.

In the Kaffir War of 1846, near Block Drift, a 12-pounder howitzer was rendered *hors de combat* by a high shot sticking in the bore.†

PRACTICE VERSUS THEORY.

The practical Artillerist well understands the danger of trusting entirely to theory. It will perhaps be satisfactory to the uninitiated to have an opportunity of contrasting the following theoretical conclusions of Professor Babbage with the annexed practical results.

"If the muzzle of a Gun," says the learned Professor, "has been accidentally stuck into the ground, so as to be stopped up with clay, or even with snow, or if it be fired with its muzzle plunged into water, the almost certain result is that it bursts." *Economy of Machinery and Manufactures, page* 23.

Memorandum of an Experiment made in the Royal Arsenal, in 1835, to determine the resisting powers of a Musquet Barrel, under the conditions hereinafter stated.

1. The musquet was loaded with the Service-charge, about five inches of its muzzle was stopped with moist sand, and, in that state it was fired without any perceptible effect on the barrel. It was then re-loaded, with the same charge,—the barrel being on this occasion filled with sand,—and again discharged without the slightest injury to the barrel.

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* London Mail, January 25th, 1855.

† Vide Foot Note page 156 "Hand Book for Field Service &c." by Captain J. H. Lefroy, F. R. S., Royal Artillery.

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It was next loaded as before, and fired,—the muzzle being this time plunged into a bank of sand,—with precisely the same result, as regarded the effect on the barrel.

2. A two-inch iron plug was inserted into the muzzle of the barrel, and, by soldering, carefully secured in that situation. The breech was removed to admit the ball, wrapped in paper, and two drachms of powder as a charge. It was then restored to its place, and the musquet again discharged, without perceptible effect on the barrel. On examining the ball however, it was found to have stuck against the end of the plug, whereby its surface was somewhat flattened. The experiment was then repeated, the charge being increased to three drachms, with the same result, except that, in this instance, the impression on the surface of the ball was less that in the preceding; and, on the charge being increased to four drachms, such was the compression of the air, in front of the ball, that it never arrived at the plug,—the elastic fluid having in this, as in the two preceding experiments, escaped through the vent.

3. The barrel, having withstood these severe tests, was next loaded, as in the first experiment, with six drachms of powder, and, on its being fired, so violent was the compression of the air in front of the ball, that about two inches of the barrel immediately in contact with the plug gave way. On this occasion it was evident that the ball struck the plug subsequently to the bursting of the barrel, as it, in part, took the impression of the fracture.

"If, in loading, a space is left between the wadding and the charge, the gun either recoils violently, or bursts." *Idem.*

Memorandum of an experiment made in the Royal Arsenal, in 1837, to ascertain the recoils of a Musquet, suspended in the place of a Gun Eprouvette, loaded with five drachms and a half of powder, and the ball in contact with, and at certain distances from the charge.

Ball in contact with the charge	Recoil	44·73	Degrees.
6 inches from " "	"	37·36	"
12 " " " "	"	35·83	"
18 " " " "	"	32·70	"
24 " " " "	"	29·56	"
30 " " " "	"	26·43	"
36 " " " "	"	24·06	"
Blank, or without a Ball	"	16·43	"

Note.—The above results are each the average of three rounds, and subsequently three additional rounds were fired from the same musquet, the ball, in these instances, being jammed into the Barrel, with paper, at the under-mentioned distances from the charge.

Ball 12 inches from the charge	Recoil	35·3	Degrees.
24 " " " "	"	30·8	"
36 " " " "	"	24·1	"

"If a gun is loaded with ball, it will not kick so much as when loaded with small shot; and amongst different kinds of shot, that which is the smallest, causes the greatest recoil against the shoulder. A gun loaded with a quantity of sand, equal in weight to a charge of snipe shot, kicks still more."—*Idem.*

Memorandum of an Experiment made in the Royal Arsenal, in 1838, to ascertain the Recoils of a Musquet,—suspended as a Pendulum Eprouvette,—loaded with five drachms and a half of powder, and the charges undermentioned.

Service Ball	Recoil	42·55	Degrees.
Bird Shot, Double B	"	40·26	"
" " Number 2	"	42·63	"
" " " 4	"	43·30	"
" " " 6	"	42·54	"
" " " 8	"	41·76	"
Dry loose sand	"	38·83	"

Note.—The results given above are likewise the averages of three rounds, fired under precisely the same circumstances, and, in every instance, the charges of bird shot and of sand were of exactly the same weight as the lead balls—17$\frac{1}{16}$ drachms.

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Proportion of Ordnance Bullocks for the Artillery in the Bengal Presidency.

XVI
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No. 214 of 1855.—The most Noble the Governor General in Council is pleased to fix the following proportion of Ordnance Bullocks, to be kept up for the Artillery in the Bengal Presidency.

The number of Bullocks authorized for each Battery is as follows:

In Cantonments.

Each Troop of Horse Artillery and Horse Field Battery.

For 2 Carts in use	7

Each Bullock Field Battery.

6 Guns and Carriages, at 8 each	48
6 Waggons, at 6 each	36
Spare	15
2 Carts	7
Total...	106

On Service. (Additional.)

Each Troop of Horse Artillery, Horse and Bullock Field Batteries.

6 Extra Waggons at 6 each	36
Spare	6
3 Carts at 6 each (less 7 in use)	11
Spare	3
1 Spare Ordnance Carriage	6
Total...	62

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On ordinary occasions, on the march in course of relief, or for the purpose of Practice (additional.)

Each Troop of Horse Arty., Horse and Bullock Field Battery.

3 Carts at 6 each (less 7 in use)...........................	11
Spare..	3
1 Spare Ordnance Carriage..................................	6
Total...	20

The Bullocks allowed for Batteries in Cantonments will always be under charge of the Officers Commanding. Those authorized on occasions of service and on the march will be ordinarily under charge of the Executive Commissariat Officer at Stations, and will be transferred to the Officer Commanding, on the Troop or Battery receiving the order to remove.

Ordnance Bullocks will, under the present distribution of Troops and Batteries, be kept up at the following Stations:—

Number of Transport Train Bullocks allowed for Troops of Horse Artillery and Light Field Batteries of the Bengal Artillery.

Stations.	Horse Arty. and H. L. F. Batteries.	Bullock Batteries.	Bullocks allowed in Cantonments.	Additional on Service.	Total.
Agra..	0	1	106	62	168
Benares ..	0	1	106	62	168
Bareilly	1	0	7	62	69
Dum Dum.	1	0	7	62	69
Dinapore	0	1	106	62	168
Delhi ..	1	0	7	62	69
Ferozepore	1	0	7	62	69
Govind Ghur	1	0	7	62	69
Hoshearpore	1	0	7	62	69
Jhelum ..	1	0	7	62	69
Jullundur	2	0	14	124	138
Lucknow..	0	1	106	62	168
Lahore	3	1	127	248	375
Meerut ..	1	0	7	62	69
Muttra	1	0	7	62	69
Mooltan ..	1	0	7	62	69
Nowgong	0	1	106	62	168
Peshawur...	4	0	28	248	276
Pegu..	2	0	14	124	138
Rawal Pindee	1	0	7	62	69
Sealkote	3	0	21	186	207
Umballah ..	2	0	14	124	138
Total..	27	6	825	2046	2871
Grand Total..	33	..	..	2871	..

XVII
2

Bullocks will be kept up for the Post Guns at the following Stations.

Statement of Post Guns requiring Bullocks.

Stations &c.	Guns.	Bullocks.	
Ramghur Battalion	4	56	
Sylhet	2	28	
Berhampore Post Guns	2	28	
Dacca do.	2	28	
Futtyghur do.	2	28	
Gorruckpore do.	2	28	
Jhansie do.	2	28	
Khyook Phyoo do.	6	84	
Shahjehampore do.	2	28	
Total..	24	336	

The Establishment of Bullocks for Siege Trains will be

Siege Trains.		Number of Bullocks allowed.	No. 1. Train. Carriages.	No. 1. Train. Bullocks.	No. 2. Train. Carriages.	No. 2. Train. Bullocks.	No. 3. Train. Carriages.	No. 3. Train. Bullocks.	No. 4. Train. Carriages.	No. 4. Train. Bullocks.
1st Class.		Bullocks.								
Arsenal		24 Pdr. Carriages at 26 each	12	312	6	156	4	104	2	52
Allahabad	1528×4=	Spare........ „ 22 „	2	44	1	22	..	....	..	....
Agra	6112	18 Pdr. Carriages „ 22 „	12	264	6	132	4	88	2	44
Ferozepore.		Spare........ „ 18 „	2	36	1	18	..	....	..	....
		10 in. Howr. Car. at 26 each	4	104	2	52	1	26	2	52
2nd Class.		Spare........ „ 22 „	1	22	..	....	..	....	..	....
Cawnpore.		8 in. Howr. Car. „ 22 „	6	132	4	88	2	44	2	44
Delhi.		Spare........ „ 18 „	1	18	1	18	..	....	..	....
Phillore.	812×5=	Cart Store or Artificers. „ 6 „	30	180	16	96	8	48	6	36
Peshawur.	4060									
Rangoon.		„ Platform. „ 6 „	27	162	15	90	9	54	6	36
3rd Class. Mooltan..........	438	Car. Transport Medium. „ 12 „	3	36	2	24	1	12	1	12
4th Class. Attock............	322	Total..	..	1310	..	696	..	376	..	276
		One-sixth spare..	..	218	..	116	..	62	..	46
	10932	Grand Total..	..	1528	..	812	..	438	..	322

Ordnance Bullocks kept up for Siege Trains will be distributed at magazine and neighbouring Stations at the discretion of the Commissary General. These Bullocks are to be entirely under the charge of Executive Commissariat Officers, who are to be responsible for their care and condition. They are to be available for Magazine work and the transport of Ordnance Stores between Magazines and from Magazines to neighbouring Stations and while so employed, the

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responsibility for their proper care will devolve on the Officer under whose orders they are employed, or the "Warrant Officer or person proceeding in charge of the Stores.

Abstract.	Bullocks.
Present with Light Field Batteries...........	825
,, ,, Out Post Guns............................	336
Required for Light Field Batteries when on Service...	2046
,, ,, Siege Guns........................	10932
Total...	14139

Bursting of Cannon by Red-Hot Shot.

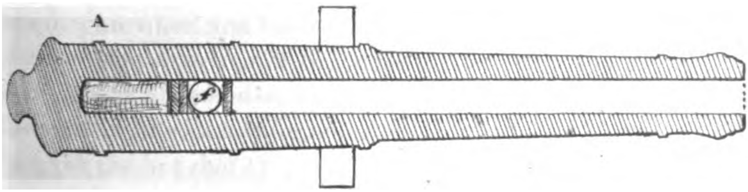
"It may be added that when a red-hot shot is allowed to remain any length of time in the bore of a gun, the heat communicated to the metal causes a contraction of the diameter at the seat of the shot, which is probably the cause of some recent fatal explosions. (vide Addenda to "Hand book for Field service &c." by Captain J. H. Lefroy F. R. S. Royal Artillery.)

During the celebrated Siege of Gibraltar, it was the subject of general remark, how many of the guns of that garrison burst when loaded with red-hot shot; and it was then attributed to the fault of casting the guns hollow. In the absence of any satisfactory explanation respecting the *recent* unfortunate accident with red-hot shot, at Malta, attended as it was with such very melancholy results to some of the garrison, we may observe that Mr Gearing has ventured to suggest, as a probable cause of the late catastrophe—that the *bore* of the gun was *contracted* by the red-hot shot *expanding the metal of the gun*, and by its local contact for ten minutes, which would tend to plug up the gun fixing the shot in the bore, in the immediate place of contact. Thus, from the

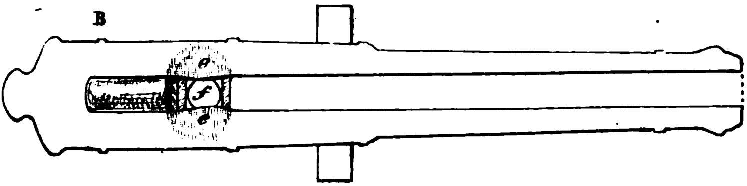
Miscellaneous.

Bursting of Cannon by Red Hot Shot.

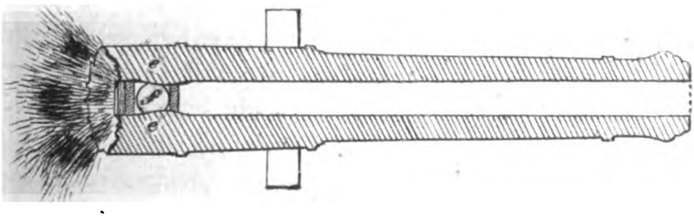
A



B



C



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great inequality in the expansion of the metal, consequent upon the *inequality of temperature*, the shot is fixed; and the gun burst in the line of least resistance, at the moment of explosion.

The strict investigation of the principles which influence the bursting of guns, having for their object the prevention of any similar accidents for the future, must, in our present critical political relations be hailed with lively interest. And it is to be hoped that timely rectifications will secure the safety of the garrison and the honour of the country, during a period of actual warfare.

In the diagrams, (Plate 15) letter A represents an ideal section of the gun when first loaded.

B to represent a section of the same gun *after* the red-hot shot has been in *ten minutes*; exhibiting the local expansion of the metal of the gun internally, at (*e*), produced by the contact with the hot shot (*f*), and the consequent *contraction* of the bore.

C—the same gun burst in the line of least resistance, at the moment when the expansion has fixed the hot shot in the contracted bore of the cannon; and weakened by great inequality of temperature.*

Shelter from an Enemy's Fire.*

At the siege of Mayence, in 1793, the following method of sheltering the workmen from the enemy's fire, was used with great success, during the construction of the Batteries:—

It was towards the end of the siege that Lieutenant Néandre received orders to construct a battery 130 paces from the counterscarp, the covered way being strongly occupied by the enemy. Lieutenant Néandre, foreseeing the difficulties that would occur, provided himself with 120 common platform planks, and when the gabions were in their places, arranged the planks outside them, in such a manner as to present an inclined plane towards the enemy; the gabions were then

* United Service Magazine,—July 1854.

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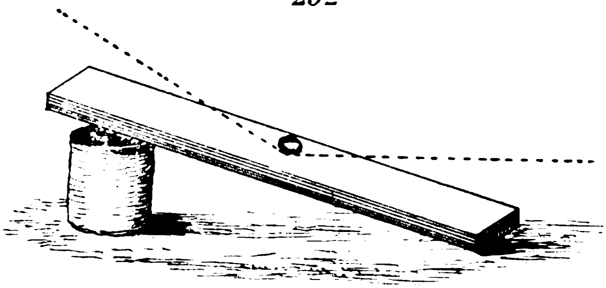

half filled with earth and the pickets driven in. At this moment, the enemy, perceiving what was being done, threw some fire-balls and fired a few shot, all of which went over; but soon after, the workmen were assailed with a well-sustained fire of musketry; but on the balls striking the epaulment they ricochéd and passed over the workmen so that not a single man was hit. The battery was finished in a few hours, when the planks were drawn in and used for the platforms.

Lieutenant Néandre having obtained leave in 1803, to make some experiments on this description ef shelter, obtained a number of planks nine inches thick, but partly worm-eaten, being part of an old house then in course of demolition; with these, and a sufficient number of supports, he constructed an inclined plane, which was to be fired at from a battery of 12 guns 300 paces off. These preparations met with much ridicule; but Néandre was so confident of the sufficiency of the epaulment, that he and a corporal placed themselves secretly under it, and quietly waited for the effect of the fire. He had, however, forgotten an important circumstance; for when upwards of thirty shot had struck full on the plane of the wood, ricocheting to a considerable height, the pressure of the beams forced the legs of the trestles upon which they were supported into the sand, to such an extent, that the inclined plane was on the point of being levelled, so that Néandre and his companion had to beat a retreat. The fire was then continued (though Lieutenant Nèandre begged that planks might be placed under the legs of the trestles), and the epaulment in this manner destroyed, without, however, a single beam having been penetrated or even split.

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On the expediency of arming Artillerymen attached to Light Field Batteries, with Revolving Pistols.

Communicated by Lieutenant A. Stewart, Madras Artillery.

To

The Director Artillery Depôt,
Saint Thomas' Mount.

SIR,

I trust that the interest which all Artillerymen must feel in the question, "what is the most efficient small arm for our men," may plead as my excuse for troubling you with this letter; but as recent experience in the Crimea has proved the utility of that most portable arm, the revolving pistol, as a weapon of defence for *individuals*, I am the more emboldened to give publicity to a long considered project of my own; viz. the expediency of arming our light field battery men therewith.

As the subject is of paramount importance, I trust my suggestions may be received by you and early submitted to that scrutiny which all professional papers meet with, when published in the "Records" of our Corps: and that I may be pardoned, should the interest I feel in the subject, cause me to write too long a letter thereon.

II. In examining the question, it may be as well to commence with a few remarks upon the present equipment of Artillerymen.

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I refer to that published in G. O. C. C. No. 74, of 12th November, 1853, and which (although not yet carried out) is, I understand, the established "small arm equipment" of our Regiment. The efficiency of this system I do not at present question, as far as the "*Reserve*" Companies are concerned; this letter having reference only to Light Field Batteries.

III. With the exception of the eighteen Carbines attached to the Battery, as part of its stores; and which, under present arrangements, are scarcely available in any case of sudden emergency in the field, the only weapon of *personal* defence, with which the field batterymen are armed, is a short sword, (only about 30 inches in length) and they are taught the "Infantry Sword Exercise;" that is on foot and with *extended files*. Now, the above arrangement naturally led me to the question, "Against what description of troops "would this mode of defence be adopted?" for certainly Cavalry (putting Lancers out of the question,) could not be received with any chance of success, by foot soldiers, each acting independently, and furnished with the same description of weapon as his antagonist, but with the disadvantage of its being much shorter. The fate of the Russian Artillerymen at Balaclava, when our light dragoons got amongst them, has forewarned us to pay attention to this subject: may it also fore arm us, should we ever be placed in a similar position! But to return. As certainly, Infantry could not be individually opposed with safety by this same short weapon; and if neither Cavalry, nor Infantry are met, save on the most unequal terms, the question recurs, "against "whom is the short Artillery sword to be used?" Again, when seated on the limber, I defy any man with this weapon, to reach either a mounted, or dismounted opponent: (barrin' his *Comrade* on the next box!) and the conviction has accordingly been forced upon me, that it is a most useless arm.

In addition to the above, it is very much in the way of a

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man's performing his duties with alacrity: as any one may satisfy himself, by attempting, when thus armed, to do the duty of No. 6 at the gun, or to mount and dismount from a limber, or even to sit thereon with comfort.

It may not be irrelevent to mention here, that Horse Artillerymen are also armed with a pistol, although their sword is a much more effective weapon, than the present foot Artillery abortion.

IV. Now, with regard to the revolving pistol, there is no such inconvenience. It and its ammunition are most portable; and a man on the limber, or when sponging, or otherwise serving in any duty at the gun, if thus armed is completely a match for a single opponent.

V. It may be said a pistol is uncertain, even at a short distance. I reply, "true, then stick to your gun;" and the following should be well inculcated into every Artilleryman's mind, viz. "As long as your enemy keeps at a distance too "great for *personal* assault, your gun is the most destructive "weapon you can use: and if a man come near enough to "strike you with sword, or bayonet, *then* take to your pistol "and shoot him; he will be near enough to make you sure "of your aim." On emergency, the revolver could be used by No. 4 with his right hand, whilst he serves the vent with his left; or in the left hand of No. 5, whilst he has the portfire in his right: and as, owing to the number and variety of his duties, an Artilleryman must, of all other soldiers, be the most cool and collected in action, he is the man least likely to make mistakes, even with a compound weapon.

VI. Should this proposition be favorably received, the mere questions of detail—(such as the number of barrels that would be most convenient for Artillery revolvers, their dimensions, the mode of fixing them in the belts, &c.) could be soon solved by a Committee of experienced Officers.

VII. I have written to Messrs. Deane and Adams, to ask

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on what terms they would supply their five-barrelled revolvers, of the medium size. I will send you their reply, when received: but I have no doubt that, when the cost of the present sword (complete) is deducted from the amount they may ask, the balance will not entail on the Government any expense that could for a moment be placed in comparison with the advantages to be gained in point of efficiency, and of saving the very expensive lives of Artillerymen.

I have the honor to be, &c.

MOULMEIN, 30*th March*, 1855. (Signed.) ALEX. STEWART, Lieut., *Comg. Artillery Moulmein.*

P. S.—Since writing the above, I see by the Mail just arrived, that orders have been issued by the Naval authorities at home, to arm boarders, Warrant Officers, Sailmakers, &c. with revolvers: and Government has entered into a contract for the supply of 3000 revolvers to the Army in the Crimea. In half the little episodes of the war, this destructive weapon is prominently mentioned: and in a recent attack by the Afreedees on Lieut. Hamilton's Camp, it is stated that he "shot one or two with his revolver, *which deterred the rest from closing with him.*" What chance would he have had of escaping, had his weapon of defence been an Artillery short sword? It must also be remembered, that when Cavalry, or Infantry get among the guns, the fight becomes resolved into a series of *isolated individual combats.*

A. S.

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Cause of the bursting of Iron Guns when firing Hot Shot.

Communicated by Lieutenant C. T. COLLINGWOOD, *Madras Artillery.*

To

The Director Artillery Depot.

SIR,

I see in the last Records an extract from the U. S. Magazine proposing to account for the cause of Iron Guns bursting when firing hot shot.

The reason given is, that the bore is contracted by the heat of the shot.

Heat can never contract the bore at the seat of the shot. The very effect of heat is expansion or enlargement. The ultimate particles of the iron are *repelled* from each other by heat, and to form part of the periphery of a smaller circle than the bore of the gun originally was, they must be packed together more closely, or *attract* each other. Witness moreover the practice of tiring wheels with a hot tire which is perceptibly larger than when cool.

Is this not sufficient to account for the greater frequency (?) of guns bursting when firing hot shot (without resorting to any mechanical bunging up of this kind)—that heat is the great antagonist of cohesion, that the atomic particles of a gun would not stick together so strongly when hot as when cold—that owing to the unequal expansion of the metal or to its attempts at expansion checked by the exterior surface of the gun being of a lower temperature than the interior of the bore, there would be a tendency to disruption—(remember the very common accident of a tumbler cracking when hot water is poured into it) and finally add the increased strength of the powder from its more perfect and instantaneous combustion at a higher temperature (although slight-

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ly reduced as to quantity) and the lessened windage from the expanded hot shot.

I have never seen any full reports of an enquiry into the cause of accidents of this kind—that is, which gave the age of the gun, and the work that it had done. Cast iron guns the more used they have been the more liable they would be to burst from the deterioration the metal undergoes from percussion and the jarring of the shot in the bore. Cast Iron becomes particularly brittle—the arrangements of its atoms quite changed, by percussion. Several accidents in the wheels of railway carriages have been traced to this.

I see now they have begun to talk about wrought iron guns or a mixture of wrought and cast iron. A wrought iron shell or case for a bore is made and then a casting to be made on this, to lessen the chance of accidents.

I hope as the Records have published one reason for the bursting of guns firing hot shot, you will also publish these I now give: let my brother Officers judge which they think the right.

(Signed.) CARLTON COLLINGWOOD, Lieut. *3d Battalion Artillery.*

SAUGOR, *May* 31*st*, 1855.

NOTE.—The reason given in the Extracts from "Lefroy" and U. S. Magazine in the Records for April (Miscellaneous page 290) is that, *the heat communicated to the metal by the red-hot shot, expands it, and causes contraction of the diameter of the bore at the seat of the shot.* If the shot's heat be sufficient to expand the metal, it must of necessity proportionably contract the diameter of the bore,—for the expansion acts in all directions, and is greatest at the surface of the bore in contact with the hot shot:--whether the expansion of the shot, and contraction of the diameter combined, would suffice to fix the shot so as to cause the gun to burst (see the interesting Extracts from Spearman's "British Gunner," 5th Edition, 1854, in Artillery Records for March, "Miscellaneous," pages 284 to 286 on this subject) may appear questionable, considering how soon the shot cools between two soaked wads, but that the expansion of the gun metal, if it occur, *must* diminish the bore, seems indisputable. (AG. D. A. D.)

System of Breaching arising from the Bapaume Experiments.

To breach the face of a work with the common breaching battery, that is to say, one established in the crowning of of the covered way of a face, or in the covered way itself, the position of that battery should be determined so that the lines of fire of the guns, should make, together with the revêtment, an angle, measured in the horizontal plane, comprised between 50° and 90°. The harder the masonry is, the more open this angle should be, and care should be taken to avoid placing the battery quite parallel to the face it is to breach. The essential point is to have a direction of fire such that the shot will not ricochet. In most cases, the best position for fulfilling all the conditions of the breaching fire, will be near the saillant of the covered way of the work, whence the guns can be directed against the faces of that work, at an angle of about 60°, and at a good distance for firing. This position will, besides, not require for the establishment of the battery, more earth-work than any other position on the crowning of the covered way.

The most convenient height for the position of the horizontal cutting is one-third of the total height of the escarp, measuring from the foot. This height is quite sufficient to enable the materials placed above forming by its fall a ramped, covered all over by about a yard of earth; on the other hand, it is sufficiently high to prevent the horizontal cutting being obstructed by the rubbish accumulating at the foot of the wall. This position is also visible, in most cases, from a battery placed in the crowning of the covered way. In those circumstances in which this height of one-third should not be visible from the battery, the position of the horizontal cutting may be raised to one half of the escarp.

The position of the horizontal cutting being determined, the following directions will be followed to form a breach twenty yards in length, with a battery of four guns, at an angle such that all the shot will penetrate. After having divided the extent of the proposed breach into four equal parts, corresponding to the four guns of the battery, each gun will be directed to the extreme right or left of its as-

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signed portion, and the first round will be thus fired. The guns will then be directed to one side of their former aim, proportionally to the effects of their calibres, that is to say, about four feet for 24 pounders, and three for 16 pounders. A second round will then be fired, and subsequently the guns will be directed, left or right, this distance from the former shot, until the horizontal cutting is clearly traced out. The same thing must then be repeated, the guns being pointed at the centre of the intervals between the first number of holes, after which they are directed indiscriminately at all the saillant points. But whatever plan may be adopted in this matter, one cannot too much deepen the horizontal cutting. Experience has demonstrated that the fall of the revêtment and the perfecting of the breach depend greatly on this cutting. The deeper it is made, the more the mass above will endeavour to detach itself from its supports; and, consequently, the less labour there will be with the vertical cuttings.

The best index for discovering when the horizontal cutting has been sufficiently deepened, is the falling of the earth of the rampart, which shows that the revêtment has been penetrated through. Yet this index is sometimes wanting, as for instance at Bapaume, where the revêtments were of great thickness, and the earth very hard. In such a case, one may be guided by the height of the horizontal cutting above the ditch; when it will appear to have a depth equal to its height above the ditch, then this cutting may be supposed to be sufficiently advanced.

As a general rule, two vertical cuttings, traced on at each end of the horizontal cutting, so as to isolate completely the block of masonry wanted to be detached, should suffice. Intermediate vertical cuttings are inconvenient, owing to their diminishing the weight of the mass, and thus lessen the action of its weight, and fill up the horizontal cutting and the middle of the breach with the rubbish, which might cause serious inconvenience by stopping, when the revêtment falls, blocks of masonry, at a height where they cannot be covered by the earth of the parapet. Intermediary vertical

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cuttings must therefore only be made in very exceptional cases; for example, in masonry, the materials forming which have a powerful consistency, or where the counterforts are connected with the revêtment in such a manner that it could not be otherwise destroyed; but this is seldom to be met with.

The vertical cuttings should be commenced at their base, and in the horizontal cutting itself, and the angle thus formed must be thoroughly cleared, as rubbish might otherwise accumulate. A shot will then be fired four feet above this point, and a second shot in the centre of the interval between that point and the angle; and then the firing will be continued against the saillant points intervening, until that portion of the cutting is completed; a fresh space of four feet upwards will then be done in a similar manner, if necessary. By following out this plan in masonries of medium resistance, as those of Bapaume, it is very seldom that it becomes necessary to carry the vertical cuttings higher than half the space comprised between the cordon and the horizontal cutting. If, however, it were to happen that the vertical cuttings were carried up to the cordon, and the revêtment did not appear likely to turn over, the battery should be fired in salvo into the horizontal cutting, particularly towards its extremities. If this did not succeed, recourse must then be had to the formation of one or two intermediary cuttings; but every now and then firing a salvo into the horizontal cutting.

When only two vertical cuttings are to be formed, each of them should be executed by the section of two guns in front of it. When more than two, then the guns should be divided according to the number of cuttings, taking care that each cutting keeps pace with the others so as to avoid any irregularity in the fall of the escarp.

The fall of the revêtment generally carries away with it those of the earth of the parapet, as far as the middle of the part destroyed, and thus leaves uncovered the upper part of the counterforts, to which, portions of the posterior face of the wall remain attached, more especially towards the extremities of the breach. When the earths are very hard, as at Bapaume, only that portion which reclined more immediate-

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ly against the revêtment will fall, and the remainder forms a new escarp, in which only the roots of the counterfort are found. In both cases, however, if the fire is nearly direct, it would be better to cross the fire of the sections of the battery, so as to take the counterforts obliquely. The fire should also be as low as possible, that is to say, at the top of the fall of earth, raising the guns gradually as this fall increases. A similar fire will be carried on to sap the earth, after all the masonry has disappeared. The effect of the shot is sufficient, even in very strong earth, to cause the parapet to fall and complete the breach.

In executing a very oblique breach, the only difference consists in forming the horizontal cutting. By an oblique breach is to be understood, one formed at such an angle that the shot might ricochêt off the revêtment instead of penetrating into it; therefore if the chance of ricochêt is considerable, each piece must be directed in that portion of its range which is nearest to the battery, and thus a first salvo will be fired. The pieces will then be pointed at these first holes, so as to lengthen them and deepen them in the direction of the horizontal cutting, and the same will be continued until the four openings join, and thus form but one.

If the revêtment is hard, and that too many shot will be lost by the ricochêt, all the guns will be directed first of all at the extremity of the horizontal cutting nearest the battery, and the fire will be opened with the piece which can be aimed at the most open angle.

The destruction of a breach by a mine, is to place that breach as it was after the fall of the revêtment, without the rubbish, and to make it again serviceable requires the same number of shot and the same time as at first. This is, however, only in case the battery is direct, or only very slightly oblique. In case of its being very oblique, it would be difficult to re-open the breach with the same battery, because it could no longer see the bottom of the breach. In such a case, the battery must be brought closer, or the breach be widened in that direction.

Colburn's U S. Magazine for March, 1855.

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Trajectory of Shells, communicated by Lieutenant Colonel P. Anstruther, C. B.

To

The Director of the Artillery Depot.

Sir,—1. I look upon the Parabolic Theory of Projectiles as a valuable hint as to the real path of a body projected, and I think we might, with a modification of this curve, arrive at something very like the true Trajectory of a Shell.

2. The Parabolic theory is this,—Let A H be any horizontal line which I will suppose to be 121, divide this into eleven equal parts, of 11 each and erect 10 perpendiculars. Draw a line from A at an angle of 45° cutting each of these ten perpendiculars, the length of the perpendiculars will be 11, 22, 33, 44 and so on. From these intersections successively mark off 1, 4, 9, 16, 25, the squares of the times, and join the points, you have the Parabola, the curve of the Projectiles' course, which in our supposed case would range $121 \times 16\frac{1}{12} = 1946\frac{1}{12}$ feet or 648 yards 2 feet 1 inch.

3. But this supposes that the body is projected in free space and with uniform velocity. Now we have really nothing to do with free space and cannot give uniform velocity. But we can lay off, instead of eleven equal spaces of eleven each, the real horizontal range for each second, which is $2t—1$, that is for 11 seconds it is 21, for 10 seconds it is 19, and 21, 19, 17, 15, &c. the sum of which will be 121. At these distances, and not at equal distances, erect your ten perpendiculars, and mark off, exactly as before, join the points and you have the Trajectory, not a Parabola, but the true path of the Projectile.

4. I forward two drawings Fig. 1 and Fig. 2 shewing the Parabolic Curve, and my proposed Trajectory, if you will give them early insertion in the Records, I will prepare some further papers shewing the application to other angles of elevation, and, I think, I can show how to get the real initial velocity from the range, but of this I am not confident.

Your Obedient Servant,

Madras, October 28th 1855. P. Anstruther, Lieut. Col.

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Proposition for obtaining Ranges for varying Elevations, com municated by Lieutenant Colonel P. Anstruther, C. B.

To

The Director of the Artillery Depôt of Instruction.

Sir,—A Table of Ranges for varying elevations is very much wanted, as our rules on this head are absurdly incorrect.

I recommend that you should use either a long 8 inch gun, the longest 68 Pr. available, or if there is one handy, a 10 inch gun or howitzer—Great length of bore is the one point of importance, so as if possible to ensure the combustion of the whole charge--A compound shot, that is a shell run full of lead, will be the best projectile, and I hope you will give us a truly accurate Table of Range for Elevation.

If it is a 10 inch Howitzer you use, I should say a shell run full of lead, with 8 lbs of powder would do; if a 68 Pr. I should say 6 lbs. of powder with its shell run full of lead and I hope you will give us ranges, real, for 5°, 10°, 15°, 20°, 25°, 30°, 35°, 40°, 45°, 50°, 55°, 60°, 65°, 70°, 75°, and 80°. Perhaps 85° would be dangerous, I should like to try both 85° and 90° (!) fire by a train or fuze and run for your life! Good observations of time of flight should be made, taken with some better instrument than our present mode of counting seconds, viz. a bullet and string.

This is really much wanted, 16 rounds, say each repeated twice or even thrice would give us a valuable fact, on which to base theory.

I am going to get these ranges with a long 68 Pr. but only with a 2 ounce charge, shell filled with lead. Will you make a move in favor of detonating tubes for all Guns and Mortars, or must I?

Your Obedient Servant,

P. Anstruther, Lieut. Col.

Madras, October 30th 1855.

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Plate. 16.

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Failure of Nasmyth's Gun Experiment.

TO THE EDITOR OF THE MINING JOURNAL.

Sir,—An article under this heading is running the round of the press, with the probable usual result of newspaper paragraphs when frequently reproduced—that of credence by the public at large. That the experiment has failed is, I presume, a correct statement, because up to the present date it remains uncontradicted; but for that reason we are by no means justified in the final conclusion, that wrought-iron is an unfit material to be used in the fabrication of heavy pieces of ordnance.

We have nearly 20 years' experience of the value of malleable iron in very heavy masses, such, for instance, as shafts for large paddle-wheel steam-ships: these are now of very great weight, and are found to be equal to the most severe torsion. Ponderous cranks are forged without a flaw, and anchors weighing 4 and 5 tons are manufactured, capable of successfully resisting the maximum amount of strain. It is true that the expansive force of gunpowder is enormous, but I still think that iron can be forged with a good fibre in masses equal to the dimensions of the largest cannon required in warfare, and of reliable strength to resist the force of exploded gunpowder.

It is much to be regretted that the skill and courage so worthily evinced in Mr. Nasmyth's experiment should have been unsuccessful, though the result only exhibits the difficulty in treating wrought-iron in heavy masses, but by no means proves impossibility. Indeed, the operations carried on daily in large engineering establishments, especially in those dedicated to the manufacture of marine engines, show clearly to the public that malleable iron can be converted into any shape, and almost any weight. Let us, therefore, entertain the hope that, by adopting a different method of aggregating the metal, we may yet be enabled to turn out vast pieces of ordnance in wrought-iron, capable of resisting the shock and expansive strain of frequent firing with heavy charges of powder.

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It is true that further or even continuous instances of failure would not be attended with evil effects to the war; for, after all, it is probable that cast-iron is the true material for large cannon—not only by reason of the soundness that can always be insured by a proper head of metal, but also that, from its uniform crystalline structure, it is more capable of resisting the effects of continuous firing and high temperature than the same metal in the malleable state.

Still it is highly desirable that no check or popular prejudice should be opposed to experiments on wrought-iron, when the object is to test it under forms hitherto unknown to science, or in masses of unusual size and weight, for these attempts often lead to useful and valuable discovery.

Yarmouth, Sept. 12. 1855. LIONEL BROUGH.

Mr. H. M. Noad, the professor of chemistry, has forwarded the following communication on this interesting subject to the *Times*:—" Nasmyth's gun is said to be a failure; the reason assigned being the molecular change which the iron has undergone by being kept so long in an incandescent and soft state. Most scientific persons are well aware of this remarkable peculiarity of iron, and not a few of the lamentable accidents arising from the breaking of chains, of axletrees, and sometimes even from the breaking down of iron-bridges, may probably be traced to this cause. The tendency of iron to pass from the fibrous or tough to the crystalline or brittle condition is promoted by various causes; everything, in fact, which occasions a vibration among its particles has this tendency, and I believe that this property is by no means sufficiently kept in view at the present time, when we find on all sides gigantic iron railway bridges springing up, and when the lives of hundreds of individuals are being daily committed to the safe keeping of iron chains in our mines and coal pits. My attention has lately been drawn to this subject, and while on a visit last week to an iron work in Wales I made the following experiment. Seeing a large

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quantity of iron chain lying about, and learning that, though scarcely worn, it had been laid aside in consequence of the breaking of some of the links, I examined several from different parts of the chain. I found that a single smart blow with a hammer was sufficient to snap the metal, the fracture of which was crystalline, and its brittleness such that it could, without difficulty, be broken into small pieces under the hammer. I now heated strongly in a forge some of the broken links, and allowed them to cool slowly underneath a bed of fine sand. After the lapse of 24 hours they were examined; the metal was found to have recovered its tenacity, it could no longer be broken to pieces under the hammer, and when at length, after repeated heavy blows, it did partially yield, the texture of the metal was found to be perfectly fibrous—every trace of a crystalline structure had disappeared. This fact proved that the metal was good; and there can be little doubt that the crystalline texture of the unheated links had been produced gradually by the mechanical action (vibration) to which the chain had been subjected during its use. Now, in the case of Nasmyth's monster gun, the brittleness of the metal has been occasioned not probably so much from its having been kept for a long time in an "incandescent and soft state" as from its having, while in that condition, been subjected to violent and long-continued hammering. I would suggest, therefore, as an experiment well worth trying, that the gun should, after it is finished, be submitted to a careful annealing process,—that it should be exposed to a very high temperature, and then allowed to cool as slowly as possible; by this I anticipate that the fibrous texture of the metal would be restored, and its tenacity consequently regained. I need scarcely point out the application of the above remarks to the probable condition of the metal in wrought-iron bridges. The iron must, of course, have been subjected to violent percussions during the erection of the bridge, and every locomotive, with its long rattling line of carriages, that subsequently passes over it must

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contribute a certain share in the induction of a crystalline state among the particles of the metal, and I cannot see how the inference is to be avoided that by such an arrangement of the molecules the strength of the fabric must be gradually deteriorated. The very great, the national importance of these views, should they prove to be correct, is my excuse for giving them publicity."

Iron Cannon, and Iron Tubular Bridges

Sir,—Mr. Noad's experiments on chain that had become brittle and useless are doubtless correct. In our colliery districts we fasten lengths of chain at the end of the ropes, which, after some service, are less to be depended upon than *the* ropes themselves. They then require annealing to set them all right again, and even ship's cables, which are not *so actively* used, should still be annealed after a certain time of service, which it is most important to determine.

In order to examine the subject briefly, I must begin with the question, What is cast iron? In these days of progress we may, perhaps, not be quite sure what anything is. However, it is generally supposed to be a mixture of iron and carbon as the principal ingredients, and its natural *form* is in crystals. The presence of carbon enables the atoms of iron to move freely upon each other when heated, *so as to* become fluid. The next question is; What is malleable iron? Is not the same crystallised particles, minus the carbon driven off by heat in manufacture, more or less perfectly, unable to move on each other in a fluid state, but soft and tenacious, sufficiently so to enable the crystals to be *pressed* or hammered out of their normal form, and assuming more or less a laminated form? Hence, the quality of *malleable* iron depends a good deal on the completeness with which this is effected. Wire may be taken as nearly the perfection of the operation. There is every reason to believe that in the majority of cases it is imperfectly done, and by means of the electrical action, caused by motion or vibration, the particles

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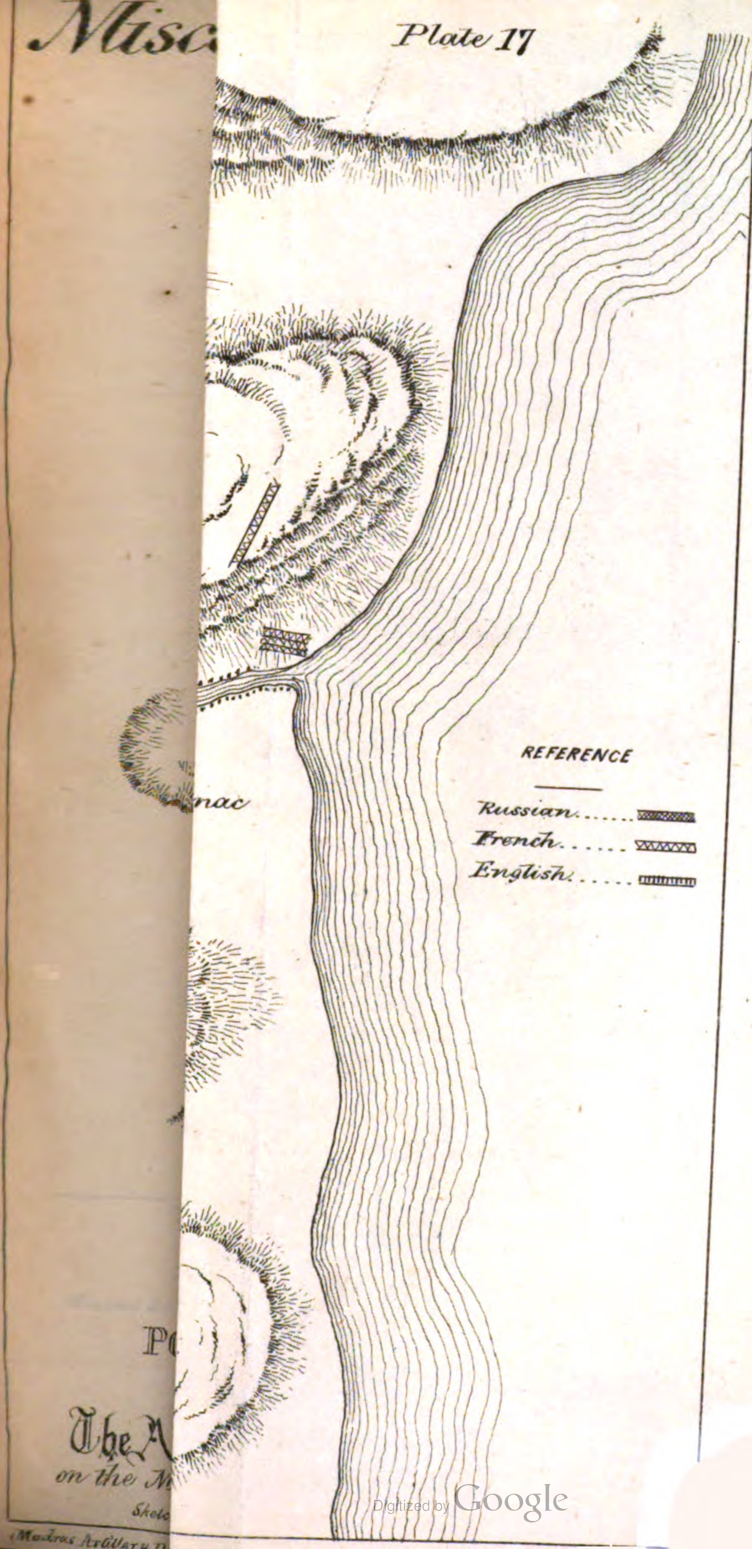
Plate 17
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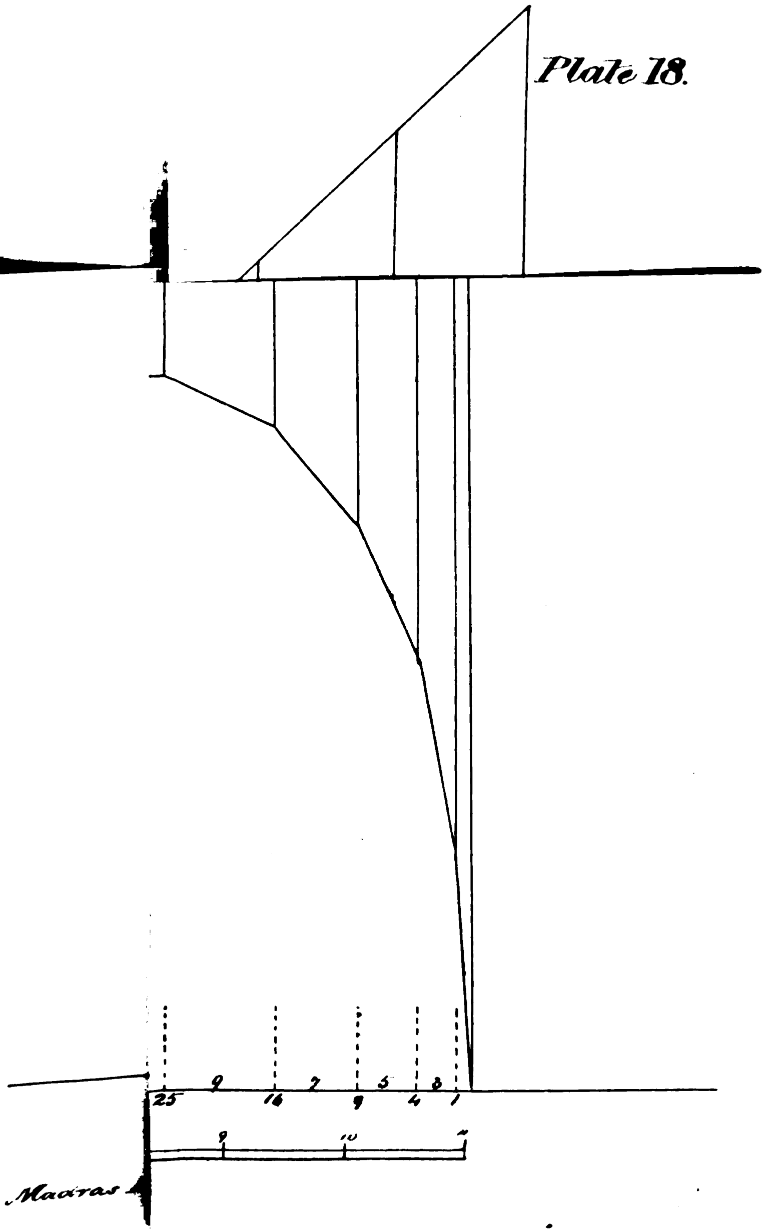
Plate 18.



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strive to regain their normal condition, and will more or less regain their crystalline form, with a speed in proportion to the intensity of this action. Colliery chains are almost always in motion.

Mr. Noad's reasoning, that "annealing changes the form of iron from crystalline to fibrous," is too much to assent to. What is annealing? Annealing iron I take to be the same process as annealing glass. I suppose it to be such a softening of the particles as enables them by attraction to bed firmly together, giving a cohesion that cannot be overcome in iron without giving the effect of friction to the broken faces, and the appearance of lamination. It is not easy to think that the expansion of a bar of iron by heat would force the crystals back into their laminated or bruised shape. However this may be, the effects of crystallisation on Nasmyth's experiment were well known by some long before it was concluded. I fear the crystals in such a mass will be too large, and the liability to imperfections too great, to allow such a manufacture ever to be depended upon. The compression of hot iron by hammering cannot be beyond the point where it is counteracted by its expansion by heat, and I believe the effect of hammering on iron to be comparatively very superficial. Notwithstanding the weight of Nasmyth's hammer, it would have little or no compressive effect on the centre of the mass of iron, but it would cause a constant vibration, most favourable to crystallisation. If the hammer could so compress to the centre, the crystals would be crushed down, and the iron would assume the laminated appearance.

I agree with Mr. Noad most fully in his remarks on tubular bridges. I cannot see how it is possible to consider them as permanent structures. Composed of thin and, therefore, well compressed pieces, they may stand a considerable time, but the effect of vibration in exciting electrical action, in forming crystals and destroying cohesion, if it be slow, will

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be sure, and you cannot anneal tube bridges *in situ*, to restore their strength.

I have a fancy that after every annealing, iron will lose a little of its original strength, and that to be equal to it, a little compression should, if possible, accompany the heating. Hydrostatic compression of a large mass of iron I have no faith in whatever. Such compression will be greatest at the surface and diminish to the centre; therefore, unequal and unsuitable for cannon. There may be a reasonable doubt whether a malleable cannon would throw its shot better than a cast one, but it would be less liable to burst, or be injured by an enemy's shot; it would last longer, and might be bored out and be as good as new, and it would stand an extra call upon its powers with greater safety. For the present I defer any suggestions, but I have no doubt of the success of iron guns, so far as making them goes.

HENRY CHAYTOR.

—*Croft, Darlington, September* 18.

Iron Cannon Cast or Wrought.

In the manufacture of ordnance, the obtaining that certain degree of strength and durability, combined with lightness, and without the incumbrance of any excessive amount of untractable weight, is the all-important subject to which the attention of practical and scientific men has been directed. Combined with this desideratum is the object of obtaining the greatest effective power from the best form, united with, and executed in, the most appropriate and fitting substance or material. Guns hitherto have principally been manufactured in iron, bronze, brass, and that admixture of copper with zinc or tin ordinarily denominated "gun metal;" although other materials have occasionally been substituted. Whatever body may be employed or used in the operation of the manufacture of guns or mortars, the question resolves itself into the following proposition—viz., What can now be done

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in order to make either cast or wrought metal guns of greater cohesive tenacity, through which they may continue uninjured by the force of that tremendous explosive power they are subject to from the discharge of a heavy loading of gunpowder and ball or shell, to the effect of which they are constantly liable? and further, Which process of manufacture is best adapted to the required purposes? However general this proposition may be, at the present time, investigators have tended, as they have been directed, to develop the intrinsic qualities of the iron required, whether in its cast or malleable state; whatever tenacity or toughness may result from the use of either original copper or its amalgams, under the denomination of brass, bronze, or "gun metal," the cost of guns so manufactured is so great as almost to preclude the possibility of those descriptions of compound metals being brought into general use, even without directly regarding the question of somewhat cumbersome weight which the metal presents, especially in the construction of cannon or mortars of the largest calibre; nor is it because these implements of warfare have been used by the Turks, under Mahmoud II., and in the Dardanelles, to an extent of 36-inch calibre, which required a charge even of 250 lbs. of powder, that this subject need be gone fully into. The material which, as an expedient, economy will suggest for present use is iron; and pursuing the subject, we should endeavour to ascertain whether for artillery or engineering purposes iron is preferable, when used in its wrought or malleable, or in its cast or moulded, state. The specific gravity of iron is certainly greater than that of copper, nor, perhaps (having regard to tenacity alone), is iron very far superior in this respect to the last-named metal. The most important subject for consideration which arises herefrom is, whether cast or wrought-iron is best adapted for the purpose specified.

In the formation of a cannon, a certain amount of gravity, or weight, is required to impart to the machine its projectile

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power, as well as to resist all strain, tension, and concussion consequent upon the explosion and combustion of the gunpowder and the discharge of the shot. Sufficient substance of metal for these purposes is all that is required; that amount which is beyond is useless encumbrance. In kind, all metals are malleable to the greater or the lesser extent; it is in the degree of extensibility as well as temperature wherein they differ. Cast-iron usually is considered to be brittle; although, under an alteration of temperature, it is capable of extension. The malleability of wrought-iron is developed by a dexterous manipulating process, from which the fibrous texture of the metal is obtained, and whereby it derives its tenacity. Cast-iron, on the contrary, existing in its natural form, presents itself in a crystallised state. The objection to the application of wrought-iron for the formation of pieces of ordnance arises from the difficulty of forging and welding in a sufficiently perfect manner so large a mass that it shall be perfectly uniform and homogeneous in its nature, combined with a proneness under certain circumstances progressively to re-assume its original crystalline form. The fibrous continuity is hereby interrupted, a degree of brittleness ensues in the place of tenacity, which under explosion, or the combustion of gunpowder, renders the material wherever this defect arises unable to resist the force of this concussion. A process by which wrought-iron, after having become crystallised, has been restored, and its fibrous character become reinstated, is, however, pursued in Birmingham, although it does not appear to have been adopted in respect of those wrought-iron cannons which recently have been submitted to the test of experiment.

The difference between the cohesive force and tenacity of wrought over cast-iron is sometimes stated to be about as three to one, although on account of the great difficulty which is always experienced in securing a thorough uniformity of substance under the operation of forging and welding iron in

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large masses, and from the molecular change which iron undergoes by frequent heatings during the process of manufacture, and through its remaining for a lengthened period in a softened state, the difference referred to generally may be stated as about two to one. In substance wrought-iron is essentially fibrous and laminated, cast-iron is necessarily crystalline. Whenever a discharge of shot is effected under the explosive influence of gunpowder, it is stated that a pressure of about 72 tons on the square inch arises, from which powerful concussion may be estimated the degree of cohesive tenacity, which is necessary to sustain so large an amount of explosive and expansive power, whether the material applied be either cast or malleable iron. The experiments which have been made in wrought-iron guns, and more especially that which resulted in the unfortunate failure of Nasmyth's guns, may still with advantage be persevered in. A different method of aggregating so large a mass as is required for a wrought-iron gun may yet be arrived at, or some improved method of annealing, or of reinstating the fibrous texture of wrought-iron may be acquired, so essential as these advantages would be to demonstrate the practicability of the adoption of wrought-iron in its adaptation to the manufacture of guns and mortars. Several further experiments have been, during the last week, proceeded with at Woolwich at the "butt" in the Royal Arsenal. Two guns were submitted on that occasion by Captain Blakesley, Royal Artillery, having wrought-iron rings combined with cast iron; this gun, an 18-pounder, burst at the first discharge. The second gun, a 9-pounder, strengthened by rings from the trunnions and the breech, stood well, as also did a 12-pounder, by Messrs. Holroyd. A 6-pounder, made of cast-steel, burst on the first discharge.

At present repeated experiments have tended to prove that cast-iron is the most covenient, appropriate, and least costly material for the construction of guns and mortars of

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the largest calibre, subject as they are to such powerful concussions, from the fact that a sound and uniform gun can always be relied upon by the use of the best-selected material, and by the exercise of only ordinary care in the moulding, heating, and casting process. The crystallisation of cast-iron is more uniform and perfect than the fibral lamination of wrought-iron; nor is cast-iron subject to the repeated heatings to which wrought-iron must be exposed. The amalgamation and agglomeration of the metal is very far more perfect, uniform, and homogeneous in cast-iron than when in a malleable state; nor is there that liability to accidental imperfections such as arise from flaw, cold joints, or imperfect welding. The forging of an enormous mass of iron of sufficient size to construct a cannon of ample substance to allow of 13-in. calibre, necessarily involves much risk and hazard, far more so than the casting of a similar body. The observation will certainly be made, that even this mass of cast-iron will be more porous in the centre than upon its external circumference;so necessarily it will be. But the same observation will be made in respect of malleable iron, the surface of which, as exposed to the hammer, will often acquire a far greater degree of density and hardness than the centre. Many of the long-continued experiments at Woolwich sufficiently demonstrated the fitness of the castings at the Low Moor Iron-Works for the purposes of cannons and mortars. The objection to cast-iron principally rests on the grounds of the excessive thickness which it is found necessary to adopt, and, consequently, its intractible weight,although where great projectile force is required to be obtained gravity must preponderate, which gravity supplies its own resisting power, and enables a greater range to be attained, and a more effective discharge to be accomplished; while the substance from which the actual weight arises provides a sufficient resistance in its own cohesive force, and this imparts that security so essential under the exercise of the combined

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and mighty powers of explosion and concussion. The foregoing statement comprises many of the advantages which are now possessed by the cast-iron gun. Nevertheless, by improvements in the manufacture of the wrought-iron gun which progressively will be realised, the latter material may yet be convertible into a formidable implement of warfare, although, perhaps, not on so extended a scale as that on which cast-iron will be used, that commodity possessing the lowest rate of cost, which always will vary.

The Americans first claimed the credit of having constructed the largest cast-iron gun ever made, which was alleged to weigh 25,000 lbs. The dimensions of this gun are as follows:—Length, 10 ft.; base ring, 39 in. diameter; length of chamber, 13.; diameter, 9 in.; leugth of bore, 9 ft. 1 in.; diameter of bore 13 in.; weight of round shot, 230 lbs,; weight of shell. 180 lbs.; range, 3½ miles.

The gun which was manufactured some litttle time since by Messrs. Walker, Gospel Oak Works, Staffordshire, far exceeds the dimensions of the American gun. The gun in its rough state weigeed 63,000 lbs., and when finished 41,000 lbs. This gun is 13 ft. long, 48 in. diameter at the base; calibre, 15 3-10ths. The shells weigh 520 lbs.; round shot, 456 lbs.

Iron Cannon, Cast or Wrought.

Sir,—However practically correct the observations in last week's Journal may be, in the comparison drawn between wrought and cast-iron in their application to the manufacture of guns and mortars, the writer remarks generally that, in the casting of cannon, the centre is always more porous and softer than the external thickness of the circumference. In all heavy castings, this difference is invariable. Referring more particularly to cast-iron pieces of ordnance, and especially to cannon, I suggest that they should be cast in a vertical position, instead of the horizontal—that is, breech down-

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wards; and that they be cast 2 or 3 feet longer than the length required, leaving the excess to be cut off, and the cannon of its own proper dimension. The effect of casting cannon in this position will be, that the quality of the metal, as well as its temper, must be more equalised. The best and heaviest metal will determinate towards the breech, wherein the greatest amount of strength is required; the gravity of the metal itself will tend to its consolidation; the cooling process will be more uniform; and, as the lightest and most porous metal will always be nearest the surface, the cutting off two or more feet from the length of the piece, as cast, will rid the entire mass of all impurities, which uniformly ascend towards the surface of every casting.

It will be remarked that casting in this position is an alteration of the usual method, and that the pattern will not draw; this difficulty can, hwever, easily be remedied by making the mould in pieces.

—*Birmingham, Oct.* 3. T. D. S.

Copy of a letter from Lieut. Colonel P. Anstruther C. B. Madras Artillery to the Superintendent of the Gun Foundry Cossipore.—dated Madras 10th November 1855, on the expansion of shells by heat.

Sir,—A series of experiments has lately been carried on at this place, Madras, from which it is concluded that by heating Shells in Charcoal fires and allowing them to cool gradually they acquire enlarged diameter and very much increased toughness.

Knowing how liable all Artillery experimentors are to find the results always confirm their preconceived theories, I request you will repeat these experiments and favor me with the details.

I shall be most happy to find that your experiments bear out those carried on here but I feel that the mere fact of the

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experiment having been tried, proves an expectation, to say the least, that such increase would take place, and I wish very much that you would verify the conclusions, or dissipate the fond hopes we now entertain of remedying, in a cheap and easy manner, the frightful excess of Windage in all our Artillery by increasing the diameter of the Shot.

But a still more valuable experiment suggests itself, and I have asked our Arsenal Authorities to try it, but some difficulty is urged as to their not having furnances of sufficient size &c. &c. &c.

I request therefore that you will try the effect of similar treatment on the Gun itself. All agree that metal expands by heating. But may not the expansion of the metal *contract* the bore? If a shell expanded by heat does not shrink to its previous dimension on cooling, may not a Gun similarly heated retain its dilatation? These points ought not to be answered by any man from his preconceived opinions, if he has the power of testing the value of such opinions by actual experiment—I have not such means at my command, but you have; and I request you will roast a cast Iron Gun in charcoal, and let it cool gradually, informing me of the result. The piece I should suggest is the 18 Pdr. because it is the largest Gun an Army can carry with it, the Royal Service, who have their Guns carried within a few miles of their work by ships and Railroads, may use Guns of larger Calibre but the 18 Pdr. is the largest Gun an Indian Army need hope to bring up to the front.

I recommend you should take 3 long 18 Pdr. *or* perhaps 8 feet Guns, if available (As the windage would authorize shortening) Calibre 5,292 and roast them well in a charcoal fire for a sufficient length of time, and leave them to cool by slow degrees, and measure the then Calibre. If, as I hope, it come down to 5·16 we should at once have the very greatest improvement that could be wished for, and I suppose at a cheap rate.

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At the same time, in the same fire, you might cook a hundred or two of 18 Pdr. shot 5·09 and if they increased also, I can hardly fix a limit to the accuracy we might obtain with our absurd old Guns and defective shot.

**On the Attainment of extreme Range from long Guns.
By Lieutenant Colonel Parkinson.**

Although among Eastern nations guns of great magnitude for defensive purposes have for a long period found favour, it is only the modern art of war that has brought to the consideration of the great powers of Europe the advantage of guns of great calibre, and the greatest possible range, but with all the desire to attain the latter, one of the first principles, *total* prevention of windage, appears to be neglected. I am aware that of late years the subject is more attended to than formerly, and that it is now an acknowledged fact, that the propulsion is greater in proportion to diminution of windage; but the *total* exclusion of windage appears to have been either overlooked or considered an impossibility. The expansion of steam and the elastic fluid from ignited gunpowder are each about 2000; the expansion being the same, we may conclude that the tenacity and power of resistance are equal. With even the smallest, the most inferior steam-engine, it is considered essential that the piston should be packed *perfectly* steam tight, so that any escape of steam is impossible, as such escape would destroy power. Now, if we consider the gun as the cylinder containing the motive power, and the ball as the piston, or body to be moved in the cylinder, with the full force of the whole expansive or explosive power, it will be evident that the ball should be packed as carefully gas-tight, as the piston is steam-tight. To a cone-shaped projectile made to fit the bore of the gun with little windage, a groove might be made at the base of the cone, and this groove packed in the same manner as a steam-engine piston, the packing confined in its place by an iron ring around it;

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passing the projectile into the gun, this ring would get pushed off by the muzzle, and pass on to the handle of the rammer, or on to the hand, inserting the cone projectile into the muzzle of the gun. For Spherical Shot, a circular iron wad or wheel, with circumference grooved, and packed steam-piston fashion, the packing secured by a ring as before stated, or by a cross lanyard, to be cut when safe within the muzzle of the gun, would answer for long-range guns; but to obtain extreme range, without a gas-tight projectile, is as futile an attempt as to expect to work a steam-engine without a steam-tight piston. Indeed, all other guns should have at least a cut wire ring passed in before the ball, exceeding in thickness the difference between ball and bore, and fitting tight round the interior of the gun, so as to fill up any space between it and the ball, thus to obviate windage, and consequent deficiency of range, power, and penetration.

It being a rule that extension of range is in proportion to increase of calibre, and density of shot, so will it be found a fact, that even the greatest present range will be increased by the *total* exclusion from escape of the elastic fluid, previous to the release of the projectile from the mouth of the gun.

C. F. Parkinson,

Manufacture of Wrought-iron Cannon.

Sir,—In the *Mining Journal* of Oct. 6 you published an article from the able pen of a correspondent on the subject of wrought-iron cannon, principally in relation to a gun lately made by me on a novel principle, described in detail in that article, and which gun, having been submitted to Lord Panmure, was subsequently subjected, at Woolwich and Shoeburyness, to a lengthened and most severe ordeal, with the view of ascertaining its extreme strength. This resulted in the destruction of the gun, under circumstances by no means satisfactory to me, only confirming the opinion adopted by myself, and fully indorsed by every engineer of eminence

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with whom I have been in communication, that malleable iron guns could be made in no other way, and that disappointment must result from every attempt to forge heavy ordnance in a single mass. The failures of, at least, two attempts recently made are well known to the public, and were foreseen by almost every mechanic who has had heavy forgings under his hands, and who knows the extreme difficulty—nay, the impossibility—of procuring these perfectly solid. Such, however, is not the case with regard to forgings comparatively small; and, indeed, on this hangs the main feature of my gun, every part of it being of a size so manageable, that I am morally assured of the perfect solidity and trustworthiness of each. In this your correspondent must forgive my entirely differing from him; and I think had he seen my 9-pounder gun he would have admitted that its final destruction, under the powerful agency of continued double charges, did not arise from the smallest inperfection in the welding, but from the gun having been constructed far too light at the breech to withstand so unwonted a proof.

In continuation, your correspondent expresses a fear that if the forgings for a small 9-pounder gun want density and solidity, how much more must those for a 68-pounder. Now, Sir, as I deny the premise, I cannot yield the deduction, especially as the forgings of large ordnance will not increase in bulk in the ratio of the calibre of the guns. I have made minute calculations of what sizes of steel-bars and iron-rings would be requisite for mortars and cannon, infinitely surpassing in size anything yet contemplated, and in these the metal need not exceed in bulk a size where perfect soundness cannot be secured beyond a doubt; for my method has this advantage, that I can pile series on series of rings upon the gun, each comparatively light, till the requisite weight of metal and strength are attained. Elaborate and apparently closely reasoned as your correspondent's article is, I do not think his objections exist except in theory. They might have wrought

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in the delicate construction of a chronometer, but would hardly be considered in the putting together of a steam-engine, or in the forming of a gun to throw shot of 1000 pounds weight. For example, he says—"If we could suppose that so many rings and thicknesses could possibly be heated to exactly the same temperature, and cool under exactly similar circumstances, we could conclude that a perfect uniformity of structure might exist."

Now, as care is taken to heat the rings only enough to expand them, without in the slightest measure destroying their density or fibre, it matters not one jot whether one be heated a few degrees more or less than its neighbour, lying beside it in the same furnace; and provided the rings are exactly the same size before heating as on cooling, they return, of course, to the same temperature, they consequently regain precisely the same relative sizes. Again, our correspondent says: "By numerous jointings the risk and liabilities of fracture must certainly be multiplied." This I deny *in toto*. The very fact of my being able to examine each part of the gun, enables me to reject any one in which a flaw is found to exist. In a large mass such might escape detection, while each sound portion of my gun goes to form a whole, perfectly homogeneous and altogether sound. The liability of fracture is, therefore, diminished instead of multiplied. I will not dispute your correspondent's position of the increased cost of malleable iron cannon over cast. It is perfectly true, and from the calculations I have made, I do not believe that wrought-iron guns could, even on a large scale, be manufactured under a cost exceeding cast-iron by at least one-half. This, however, in a matter of such vast national importance can hardly be considered, especially when the increased durability of the weapon is remembered; for it is not denied that in many respects wrought-iron is greatly preferable to cast, which is never to be trusted; in confirmation of which I need only point to the melancholy accident that

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happened at Sheerness a few days ago, and to the numerous casualties which it is well known occurred before Sebastopol, and on board men-of-war in the Black Sea, by the unexpected bursting of cannon. Indeed, I know it for a fact, that early in the siege of that fortress, at least, so great was the dislike of the French to cast-iron, that their heavy trenching-guns were of brass, a metal which entails great inconvenience in the event of rapid firing being necessary.

I believe, Sir, we are on the threshold of a new age as regards artillery, and a few years hence men will wonder how the inefficient and often dangerous cannon of the present day were tolerated so long—inefficient as projecting missiles of a size so limited; and often dangerous, not to the foeman, but to those who are laying the gun against him. I am now engaged in constructing a gun of the same calibre as the last, profiting by the lessons it (which was only the second I ever made) afforded me, and avoiding errors I would not have fallen into had I been bred an artillery-man instead of an engineer. This gun, when finished, will, I think, defy all efforts to destroy it, and will be the precursor, I trust, of ordnance so powerful and so enduring, that their deadly missiles will, in a few discharges, and from distances not now dreamed of, reduce to ruins the most massive masonry any Czar has yet erected; while, after continued firing, mortars will not, as in the case of those that poured their vertical fire into Sweaborg, after a few hours be rendered unserviceable, but will retain uninjured and unimpaired all their pristine strength and usefulness.

James Dundas.

—*Paragon Works, North Britain, Oct. 25.*

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Manufacture of Wrought-iron Cannon.

SIR,—No one can peruse the communication from Mr. Dundas, in your last Journal, respecting his wrought-iron cannon, without being pre-impressed with the high tone of liberal-feeling in which that gentleman advocates the principle his wrought-iron gun was constructed upon, nor the generous candour under which he entertains a contrary opinion. I, therefore, feel the greatest deference in continuing the controversy, although more induced, in reply, to dissect the objections he has raised, being assured of their reception in a perfectly conciliatory spirit. I can assure Mr. Dundas that I am devoid of all personal interest in the subject, having a lesser regard for the means to be employed than to effectiveness, economy, and endurance of the principle, so that, in the end, we may eliminate the construction of that piece of ordnance, which Mr. Dundas proposes to accomplish in a purely national spirit, and which I emulate.

In the first instance, Mr. Dundas states "that he does not think my objections exist except in theory: they might have wrought in the delicate construction of a chronometer, but would hardly be considered in the putting together of a steam-engine, or in the forming of a gun to throw a shot 1000 lbs. weight." Under either of these circumstances my answer is the same. Does the objection to Mr. Dundas's gun exist in theory? If so, I apply the axiom—whatever is theoretically wrong can never be demonstrated to be practically right. No integral portion of a chronometer is put together in disjointed parts, saving the compensation balance. In this, rings certainly are employed, but not welded, nor exposed to concussion or explosion: so the comparison will not apply. If the theory of the manufacture of a 9-pounder cannon, be wrong (which weighs 17 cwts.), it cannot possibly be right in a 68-pounder (which weighs 5 tons), or in the discharge of a shot 1000 lbs. weight; and so *vice versa*, even although numerous defects may be compensated for by thicknesses repeated until the adequate resistance of the shock is

obtained, and bursting rendered impossible. Clumsy expedient may, on the smaller scale, atone for many defects. The test of every cannon ought to be, whether the due amount of strength has been obtained from its relative weight of material. If addition after addition of thickness had to be repeated upou a gun of the calibre of a 9-pounder, the same operation could not be consistently performed upon a 68-pounder, until all explosive power (stated to be 72 tons upon the square inch) becomes set at defiance.

Mr. Dundas further remarks :—" Now, as care is taken to heat the rings only enough to expand them, without in the slightest measure destroying their density or fibre, it matters not one jot whether one be heated a few degrees more or less than its neighbour lying beside it in the same furnace ; and, provided the rings are exactly the same size before heating as on cooling, they return, of course, to the same temperature, they consequently regain precisely the same relative sizes." He concludes by denying *in toto* that, by numerous jointings, the risk and liabilities of fracture are multiplied. " The very fact," Mr. Dundas adds, " of being able to examine each part of the gun enables him to reject any one in which a flaw is found to exist, and which, in a large mass, might escape detection ; while each sound portion of the gun goes to form *a whole perfectly homogeneous*, and altogether sound, all liability of fracture being thereby diminished, instead of being increased."

How an integral and " perfectly homogeneous" structural whole can possibly be obtained by the extrinsic combination of certain totally distinct, disunited, and several parts, I am at a loss even to conjecture. The intrinsic quality of homogeneity is not inherent by reason of the mere contact of disjointed bodies, as I understand the term, but through the means of a thorough, real, and actual incorporation and aggregation of the constituent parts which form the whole. It is upon this first point that I either differ from Mr. Dundas, or mistake his principle, and misunderstand his term. The

very opposition of the longitudinal and transverse metallic fibre of the gun is equally at variance with that complete amalgamation which a "perfectly homogeneous" structural formation pre-supposes. This latter may, perhaps, be the end which Mr. Dundas proposes, as it is my own theory; therefore, it is only as regards the means of its attainment wherein we differ, since that which is incoherent can never realise one sound and cohesive mass. Hence my second objection—viz., the incoherence of the entire body.

I have already stated, in the *Mining Journal* of Oct. 6, that the proposition for the construction of cannon formed of four bars, placed longitudinally, edge to edge, radiated in segments, hooped together by a series of iron rings, expanded by heat, and compressed by cooling, theoretically speaking, appears in principle to be extremely accurate, and we will admit that these rings, in series, may be graduated so as to give increased strength, weight, and thickness, where those essentials are most wanted. The objection, therefore, which I hold to this principle of construction applies to neither the substance nor position in which the bars and appendages are placed, but to the many multiplied contingencies of both manufacture and material, and the various unequal expansions and contractions to which the latter, by complicated heatings and re-heatings, must be subjected. To the laminated and repeated thickness of the rings, "piled series upon series" upon the gun, joining each other but not jointed, covering but not incorporated, circumferences mutually dependent on each other but not aggregated, all of which are made of flat-bar-iron, welded at every joint, liability of fracture, I contend, is increased by this complication of repeated weldings, coverings, heatings, and re-heatings. Imperfect weldings will occur under general circumstances; unequal contractions will result, whatever precautions may be used. The heating the rings "only enough to expand" will necessarily deprive them of much of the contractile power of which they are capable, and if exerted under a higher degree of heating would materially tend

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to consolidate the entire fabric of the gun, provided the welded joints would stand the strain, at which points, however skilfully they may be united, I anticipate weakness must arise. Unequal contractions, I contend, imply unequal strength, and the unequal and expansive force of gunpowder applied under explosion will assuredly deteiminate towards the weakest spot. I, therefore, with all deference to Mr. Dundas, beg to submit that, if under the exercise of so capricious and uncertain a force the resistance of the explosion of gunpowder has to be encountered, theory should be the condition precedent. If the multiplication of the liabilities of accident are to diminish the causes of failure, if incoherence be the substitute for cohesive force, if the heterogeneous mass before described can form the cannon, the "entire whole of which shall be perfectly homogeneous, and altogether sound," it is only actual experiment which can determine the point at issue between abstract theory and those principles of constructing cannon which have resulted, not from extensive practice in their manufacture, but from a simple reproduction of the primitive formation of that piece of artillery which followed the arcobusis or tubular bow of the ancients (the original type of cannon), and of which numerous examples are now extant.

—*Oct.* 31.

On Tangent Scales, and shewing the method of fixing sights to Ordnance, and forming the scales with reference to the posicion of the sights, by Sub Conductor H. Briggs of the Ordnance Department.

The Tangent Scales applied to Ordnance, are a modification of the mathematical Tangent.

To understand the true use and nature of Tangent Scales, as well as the mode of making them, it is necessary to examine into the nature of a mathematical Tangent, and trace

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from it, the modifications required to render it applicable to Gunnery.

Every circle is divided into 360 equal parts called degrees, consequently the fourth part of a circle contains 90, and the eighth part 45 degrees. If a circle be described on paper and divided into 360 equal parts, we perceive at once, that these parts, if continued by lines to the centre of the circle, form angles with each other; the value of the angle between adjacent lines being 1°, between a first and third 2°, between a first and fourth 3°, and so on until we reach an angle of 90°, the lines of which form a right angle.

In Gunnery however it is seldom requisite that more than 45°, or one eighth of a circle should be used, but as a greater elevation than 45° is occasionally given to Mortars, Quadrants, or Instruments measuring 90° are employed; but with Guns and Howitzers seldom requiring more than 10° of elevation, Tangent Scales fixed to the breech of Guns are used instead of Quadrants.

A Tangent Scale is a modification of a Quadrant having the degrees marked on a straight line instead of a curve, and the knowledge required to enable us to make a Tangent Scale, agreeing with the curve formed by the part revolution of the Gun upon its trunnions, can only be gained by noticing the mode in which a mathematical Tangent is constructed.

In the annexed diagram, (Plate 19 Fig. 1.) a Quadrant or one fourth of a circle is described and it is divided into nine equal parts, from the point B. a line is produced perpendicular to A. B. this line is the Tangent of the Quadrant. If we draw from each degree on the Quadrant, lines parallel to A. B. and passing through the Tangent, we shall have marked on the Tangent, the degrees corresponding with those on the Quadrant, or in other words, we have a natural Tangent for the Circle, the Semi-diameter being equal to the length of the Tangent line.

Very slight examination of the diagram will show us that the length of the degrees on the Tangent, must necessarily

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vary with the distance of the Tangent from the curve, though not in value; and we see also that the value of a degree ever remains the same however much its length may vary, from other degrees formed on different circles. To render this still plainer, the following diagram (Plate 19 Fig. 2.) represents two lines forming an angle of 20°; now however longer we may produce those lines, the angle remains the same, though the circle which may be described round them, using the angle as a centre, becomes larger as the lines increase in length.

Now for a moment turning our attention to a Gun, we see why the length of a degree on Tangent Scales varies with the length of the guns to which they are fitted. Why a Tangent Scale fitted to a 6 Pdr. of 60 inches, would not answer for a 6 Pdr. of 55 or 70 inches. All Tangent Scales will give true degrees, but only when applied to Guns whose length is equal to the semi-diameter of the circle on which the Tangent was framed. A Gun measuring 27 inches from the centre of the trunnions to the base ring, will have the length of its Tangent degrees, less, than one measuring 30 inches, though as before shewn, their value remains the same.

Having now cursorily examined into the nature of a Tangent, and how it is constructed, we will observe how the mathematical Tangent has been modified to render it applicable to Gunnery, as well as why those modifications were necessary.

In the following diagram (Plate 19 Fig. 3.) the line A. B. shall represent a Gun from the centre of its trunnions to the base ring; now if we place the edge of a piece of paper against that line, and raise the end towards B. to 5° on the Tangent, we shall have placed it at an angle of 5° with its former position; but we must here observe that in raising the end at B. we have described with that end a curve, the tangent remaining stationary. In Guns however the Tangent being fixed to the breech, also describes with it a similar curve, but still retaining its position perpendicular to the axis of

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the piece, and consequently being in every position a true tangent to the curve formed by the revolution of the gun on its trunnions.

Now if we raise the end B. 5°, and measure the length of the lines, say it is 6 inches, and also the length of 5°, we find at once what the length of 1, 2, 3, 4, 5 or 6 or more degrees is for a line 6 inches in length. The slight decrease in the length of the degrees up to 50 being of little consequence in practice, all the degrees on the Tangent Scale can be made of equal length. In the above diagram we have supposed the end B. to be elevated, but in Gunnery the breech of the Gun is always lowered, therefore we must suppose the Tangent to be reversed, and the degrees commencing at 0 to count downwards as in the fellowing diagram. (Plate 19 Fig. 4.)

Now if we lower the point B. 5°, keeping A. fixed, and look along the line C. A. our sight will be directed upwards, or over the object aimed at; but if at the point C. we raise a perpendicular equal to C. B. or a height equivalent to 5°, the top of the perpendicular, and the point A. will be in line, parallel to the horizon, while the line A. B. will be at an angle of 5° with its former position. From this it is easily understood that elevating a gun to any number of degrees, is simply raising a perpendicular from the Breech, and then lowering the Breech until the top of the perpendicular is in line with the sight and the object the gun is laid for.

So far the Tangent is a mathematical one, but from the nature of the gun it must be modified, to render it applicable to Gunnery; as far as we have yet gone, we have considered the Tangent simply in reference to the length of a Gun from the centre of the trunnions to the base ring, as if all beyond the trunnions were cut away, but by referring to the next diagram (Plate 19 Fig. 5.) it will be seen how much has to be done before a mathematical becomes a Gunnery Tangent.

In the line A. B. we will take a centre C., now with the edge of a piece of paper of the same length we will depress

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B. 5° to D. and consequently elevate A. a similar height, or to E. now as before described, by erecting a perpendicular from D. 5° in height, we should find that our sight would be from B. to C., but from C. to A. we should have a line E. C. obstructing any further view; now as the elevation of A. was 5°, and the depression of B. 5°, we must add 5° more of tangent to allow of the elevation of A. to E. But after doing this, we have not affected the value of the Tangent, it still remains but 5° high; for the angle E. C. A. is equal to the angle B. C. D. and both angles are 5°.

But guns never have their trunnions in the centre of their length, and therefore we must take a new diagram, (Plate 19 Fig. 6.) and examine into the further modifications of the Tangent.

Let A. B. represent the length of a Gun, C. the position of its trunnions, and D. the length corresponding from C. to B. now by depressing B. 5° first erecting a perpendicular from it equal to 5° our sight would be from B. to C., then as before shewn by doubling the height or length of the perpendicular, our sight would be from E. to F. and from F. to G. would be another obstruction. Now the angle F. C. D. is equal to the angle B. C. H. the gun therefore is still 5° of elevation; but the distance from B. to H. is less than from G. to A., therefore we can still further add to the length of 5° on the Tangent without affecting the position of the Gun, that is the surplus of height of A. G. over H. B. must be added to the 5° on the Tangent.

The Tangent scale will then be 5° formed in the following manner:—5 true tangent degrees for length of Gun from centre of trunnions to base ring—5 true tangent degrees for corresponding length from centre of trunnions towards the muzzle; and whatever extra length that may be required, to suit the extra length of the gun from the trunnions to the muzzle.

Should the sight of a gun be placed in the centre of its length, the same rules as above hold good. The length of a

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degree on the Tangent becomes shorter as the sight approaches the breech and longer the further it recedes from it. A centre sight is useless, when the elevation exceeds the height from the top of the muzzle to the top of the base ring: if the length of a degree with a centre sight is one inch, and the height from the top of the muzzle to the top of the base ring is 4 inches, the centre sight will be useless after 4° of elevation, and if removed to double the distance the degrees would measure 2 inches.

By attending to the remarks now made it would be perfectly easy, for any Ordnance Artificer, to fix sights, and makeand fit Tangent Scales, to all Ordnance. To show how the measurements could be most easily made, the annexed diagram (Plate 20.) is drawn; the gun to which the scale is to be put, being supposed to be 10 feet long, and drawn ¾ of an inch to a foot.

On a level table of sufficient size mark a line A. B. corresponding to the true length of the gun; mark on the line the exact position of the centre of the Trunnions C., then with compasses, with one leg at C. and with the distance C. B. describe a quarter circle or quadrant D. B. divide the curve of the quadrant into 9 equal parts, and the ninth part at B. into 2 equal parts, one of which will be equal to 5°. Next, erect a perpendicular line on B. as a Tangent, and mark on it the degrees corresponding with the Quadrant, in the direction of B. to L., these will be the natural degrees, then with a rule, of the length of A. B. and fixed at C., depress B. 5°, then from F. draw a line parallel to A. B. passing through the natural tangent, this line must pass through a perpendicular line drawn parallel to the natural tangent and about 2 inches from it —where it passes through will be the top of the Gun tangent—then from the 5th degree on the natural Tangent draw another line G. this will mark a space of 5° which can then be subdivided, doubling that distance we have 10°, and any further number required. For greater accuracy however it will be safer for another 5°, or to 10°, to depress B. to the tenth degree on the natural Tangent, and mark the point of A.'s ascension to H. and from that

point draw a line parallel to A. B. or from H. to I., then from I. to K. will be the length of 10°, mark off the first 5° on the small Tangent, on to the long one, commencing at I. and on the larger space from L. to K. the remaining 5°.

On "Velocity for Charge," communicated by Lieut. Colonel P. Anstruther C. B. Madras Artillery, dated 14th January 1856.

SIR,—I send you a paper which I think would be useful, for the Records. It is extracted from p. 429 of the "Aide Memoire a l' usage des Officiers d' Artillerie."

It gives the "Velocity for Charge" for a long 24 (Piece de 24) calibre 6·0121 inches, length of Bore $121\frac{1}{2}$ inches.

It is reduced to decimal parts of the shot's weight of charge and to English feet for velocity.

It says that $\frac{25}{100}$ of the shots weights gave 1570 feet
and $\frac{33 \cdot 333}{100}$ „ „ „ „ „ 1697·3333 say 1697·34

Now we know that in "*the*" Ballistic experiment of Woolwich in May 1837, the short 6 pr. gun (Griffiths 6th Edit. p. 189), gave with $\frac{25}{100}$ of the shot's weight gave *about* 1550
and $\frac{33 \cdot 333}{100}$ „ „ „ „ „ *about* 1702

Now I think we may fairly disregard the difference between 96 and 100 and call one ounce the hundredth part of a 6 pdr. shot's weight?

That being granted, I subjoin a Table shewing the value of each ounce in a 6 pdr. charge, up to 3 lbs.

Ounces.	Velocity.	Value of each ounce.	Ounces.	Velocity.	Value of each ounce.	Ounces.	Velocity.	Value of each ounce.	Ounces.	Velocity.	Value of each ounce.	Ounces.	Velocity.	Value of each ounce.
1	250	250	11	1052	52	21	1462	32	31	1672	12	41	1764	6
2	394	144	12	1102	50	22	1492	30	32	1683	11	42	1770	„
3	504	110	13	1150	48	23	1520	28	33	1694	„	43	1776	„
4	594	90	14	1196	46	24	1546	26	34	1704	10	44	1781	5
5	676	82	15	1240	44	25	1570	24	35	1714	„	45	1786	„
6	751	75	16	1282	42	26	1592	22	36	1724	„	46	1790	4
7	820	69	17	1322	40	27	1612	20	37	1734	„	47	1793	3
8	886	66	18	1360	38	28	1630	18	38	1743	9	48	1795	2
9	946	60	19	1396	36	29	1646	16	39	1751	8			
10	1000	54	20	1430	34	30	1660	14	40	1758	7			

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I give also the Table for a long 6 pdr. calculated on the above, it will be found that $\frac{26}{100}$ gives 1744, it did give (vide Griffiths) 1740 and $\frac{23 \cdot 333}{100}$ gives very nearly 1892, it did give $\frac{24}{100}$ giving 1893. It shews strikingly how little use there is in increasing the charge beyond one fifth of the shot's weight.

I have kept no copy of this as I am overloaded with manuscripts. Pray return this and get it into the Records as early as you can. It was written to serve as part of a Book I am slowly compiling. I divide Velocity into

"Velocity for charge"—which I now send.

"Velocity for length"—in hand.

"Velocity for windage"—in hand.

But whether I shall ever reduce all my manuscripts to the shape of a Book I don't know, I will send you the fragments to serve other people, if I should not publish.

French, Piece de 24, Calibre 6·0121 inches Length of Bore 121½ inches.						Long 6 Pdr. Bore 80·14 inches.—Short not given being the same as the French 24.		
Portion of the shot's weight.	Velocity in p. 429 of French Aide Memoire.	Difference given	Differences proposed.	Velocity resulting.	How far changed.	Portion of the Shot's weight.	Velocity expected.	Difference for each fraction.
·005	160·77	88	88	=161	=		179	98
·01	249·36	76	76	=249	=	·01	277	84
·015	324·82	62	69	=325	=		361	77
·02	387·16	69	60	394	+7	·02	438	66
·025	456·06	49	50	454	−2		504	56
·03	505·27	46	46	504	−1	·03	560	51
·035	551·21	43	44	550	−1		611	49
.04	593·86	46	42	=594	=	·04	660	47
.045	639·8	39	40	636	−4		707	44
.05	679·17	72	75	676	−3	·05	751	83
.06	751·35	66	69	=751	=	·06	834	77
.07	816·97	69	66	820	+3	·07	911	73
.08	885·87	59	60	=886	=	·08	984	67
.09	944·93	59	54	946	+1	·09	1051	60
.10	1003·98	52	52	1000	−4	·1	1111	58
.11	1056·48	50	50	1052	−4	·11	1169	55
.12	1105·7	49	48	1102	−4	·12	1224	54

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French, Piece de 24, Calibre 6·0121 inches Length of Bore 121½ inches.						Long 6 Pdr. Bore 80·148 inches.—Short not given being the same as the French 24.		
Portion of the shot's weight.	Velocity in p. 429 of French Aide Memoire.	Difference given	Difference proposed.	Velocity resulting.	How far changed.	Portion of the Shot's weight.	Velocity expected.	Difference for each fraction.
·13	1154·91	39	46	1150	−5	·13	1278	51
·14	1194·28	46	44	1196	+2	·14	1329	49
·15	1240·22	43	42	=1240	=	·15	1378	46
·16	1282·87	39	40	1282	−1	·16	1424	45
·17	1322·24	36	38	=1322	=	·17	1469	42
·18	1358·33	33	36	1360	+2	·18	1511	40
·19	1391·14	36	34	1396	+5	·19	1551	38
·20	1427·24	29	32	1430	+3	·2	1589	35
·21	1456·76	33	30	1462	+6	·21	1624	34
·22	1489·57	46	28	1492	+2	·22	1658	31
·23	——	——	26	1520		·23	1689	29
·24	1535·51	30	24	1546	+11	·24	1718	26
·25	1565·04	49	22	1570	+5	·25	1744	25
·26	——	——	20	1592		·26	1769	22
·27	1614·25	33	18	1612	−2	·27	1791	20
·28	——	——	16	1630		·28	1811	18
·29	1647·02	26	14	1646	−1	·29	1829	15
·30	——	——	12	1660		·3	1844	14
·31	1673·31	22	11	1672	−1	·31	1858	12
·32	——	——	11	1683		·32	1870	12
·33	1695·28	27	10	1691	−1	·33	1882	11
·34	——	——	10	1704		·34	1893	11
·35	1722·53	13	10	1714	−8	·35	1904	12
·36	——	——	10	1724		·36	1916	11
·37	1735·75	20	9	1734	−2	·37	1927	10
·38	——	——	8	1743		·38	1937	9
·39	——	——	7	1751		·39	1946	7
·40	1755·34	18	6	1758	+3	·4	1953	7
·41	——	——	6	1764		·41	1960	7
·42	——	——	6	1770		·42	1967	6
·43	1774·92	17	5	1776	+1	·43	1973	5
·44	——	——	5	1781		·44	1978	4
·45	——	——	4	1786		·45	1982	4
·46	1791·43	6	2	1790	−1	·46	1986	3
·47	——	——	2	1792		·47	1989	3
·48	——	——	2	1794		·48	1992	3
·49	——	——	2	1796		·49	1995	2
·50	1797·99			1798	=	·50	1997	

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On the permanent expansion of cast iron by successive heatings

In the course of his pyrometric researches, Mr. Prinsep repeatedly found that, on heating a cast-iron retort from 80° up to 1800° Fahrenheit, it had, even after having again become cold, acquired each time a permanent enlargement, which, by three successive heatings, amounted to fully a ninth part of its original capacity. Each successive increase, however, was so much less than the preceding, that the first heating did nearly as much in that way as both the other two. It does not appear to have occurred to Mr. Prinsep that there is any connection between such an augmentation of volume and the expansion which occurs in the solidification of iron at the casting of it; but we shall now endeavour to show, that they are just parts of one and the same process. It is curious, that in almost every book in which the expansion of iron in congealing is mentioned, it is, without giving so much as the shadow of reason or evidence, said to be momentary or instantaneous. But in many of the innumerable forms of the castings of iron, we have often observed cases occurring which cannot be reconciled with its momentarily expanding in the act of solidification, unless it also continue to expand considerably as long as it is kept very hot; and more especially unless the parts which were first congealed continue to expand whilst they remain in contact with any of the liquid metal. This impossibility of reconciling the phenomena with a momentary expansion is particularly remarkable, when in the structure of the article cast there occurs a massy nucleus of metal with arms or leaves of more slender dimensions, proceeding from it. In that case, the interior of the nucleus is generally the last in congealing, and if so, it is almost never quite sound, there being always a deficiency of metal to complete such part of the casting as is last in congealing, which occasions it to be of a spongy texture, and, perhaps, to have cavities in it of a very different sort from those which are really owing to mere

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air bubbles. Sometimes a cavity is open through the surface, which may be owing to its occurring so near the outside that the thin crust is depressed or broken quite through by the atmospheric pressure. When a hole is cast through the middle of a massy part of the iron, by means of a previously dried core, the metal next the hole is generally amongst the last in congealing, because such a core has almost no tendency to cool it; and, therefore, owing to the foresaid deficiency of metal, the hole where it passes through the interior is usually wider than the core, and, perhaps, has one or more cavities branching off from it.

Such cases as have now been instanced are of very common occurrence; but to some people they have appeared so very paradoxical as to lead them to deny that any expansion whatever can occur during the casting. At first sight, the sponginess and cavities might, no doubt, be easily accounted for, as some have pretended to do, by supposing iron to contract, instead of expanding, at the time of congealing. But that an expansion really occurs on that occasion, is so well attested as to be placed beyond any doubt; and, therefore, such expansion, taken in connection with the preceding facts, and the important one noticed by Mr. Prinsep, leaves us no alternative but to conclude, that the final deficiency of metal is owing to the exterior crust having after its own formation, continued to expand, and thereby to acquire a greater capacity within than the mere expansion of the interior parts at the time of their congelation enables them to fill up. The sponginess and cavities which so often occur in the texture of the iron in the interior parts of an unbored cannon, and in those of Shot, seem readily referable to the same source.

Water and iron are usually supposed to follow similar laws of congelation, but their phenomena are certainly very different; for water, in place of continuing to expand, as iron may do, for an indefinite time, seems to cease to expand as soon as it assumes the solid form. We have often ob-

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served, that on exposing water in a thin vessel during intense frost, the exterior parts congeal first all round, next the vessel as well as on the top, so as to incase completely the remaining liquid with a crust of ice, which at length bursts, perhaps the vessel too, and part of the water escapes through the fissures. This no doubt is owing partly to the atmospheric pressure having prevented such crust from ever being larger than just to contain the water, and partly to the interior parts expanding subsequently to the crust having ceased to expand; so that, in place of deficiency, there is here an excess of material within. On the contrary, nothing like bursting ever occurs in the case of iron; though frequently it happens that its more slender parts, in cooling, crack or break spontaneously, from their not having been able to preserve a temperature sufficiently high to continue the permanent part of the expansion so long after congelation as the rest has done, and also from their contracting sooner than the rest by the more sudden cooling. That the temporary part of the whole expansion which obtains in cast iron at a high temperature, is so great as to exceed the permanent part, appears from the subsequent contraction which occurs in cooling, as displayed by the well-known fact, that any lengthy casting is always sensibly shorter than its pattern; notwithstanding that the walls or inner surfaces of the mould, especially when formed of soft materials, have, by yielding to the weight of the liquid iron, and to the just mentioned permanent part of the expansion, made room for some addition to all the dimensions of the pattern; so that the breadth, thickness, or such other of these dimensions as are small, generally exceed the corresponding ones of the pattern. From Mr. Prinsep's experiments, however, we may learn the very important caution, that after trying to what extent any substance has been expanded whilst hot, it should also be ascertained whether any of its dimensions have thereby undergone any permanent change. Some of the stories so often repeated regarding remarkable excep-

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tions to the general laws of expansion, are very likely referable to this kind of source. Thus glass vessels have sometimes been observed to acquire a permanent enlargement by long exposure to heat; and, in many researches, such a change in the vessel is apt to be mistaken for one of the opposite sort in any fluid it may contain. The case noticed by Mr. Prinsep being that of a little iron retort, the mass would be small and the metal thin; and, therefore, at the time it had been cast, it must have cooled so soon that it could then have had almost no opportunity of continuing to expand permanently after its solidification. Hence on being afterwards heated by Mr. Prinsep, it would likely be in state a to expand so much the more. For supposing the volume to undergo no change from oxidation or other chemical action it is probable that long continued annealing at a high temperature would give to cast iron a volume which it would not afterwards exceed, unless exposed to a still greater heat. On this principle it might be supposed that a sufficient annealing might expand all the parts in the same ratio, and thereby ultimately fill up all the vacancies of the interior; but the rigidity of the iron puts this out of the question; and at any rate, granting that the annealing did bring the parts quite close together, they would not likely be united by cohesion at a heat so far below that required for welding.

The preceding view of the subject, we presume, will be found to trace to a common source, and thereby to reconcile in a satisfactory manner, the various phenomena above mentioned, which depend upon the permanent expansion of cast iron, and have so often been regarded as paradoxical. The continued enlargement of the crust is most probably owing to some change of texture or arrangement, such as crystallization occurring not only, as is usually supposed, at the instant of congelation, and perhaps, too, before it, but continuing to go on in the solid part of the iron for a long while after, if it be kept sufficiently hot; and the nature of the mould very likely modifies this result, as it certainly does

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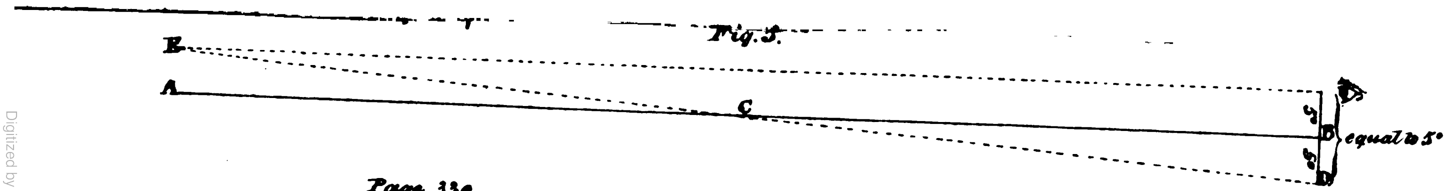
Plate 19.

Miscellaneous.

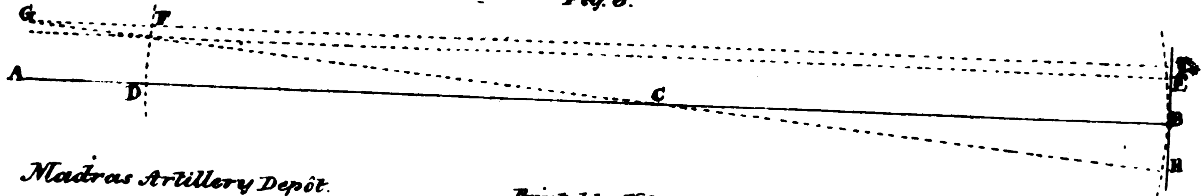
On Tangent Scales and method of fixing sights to Ordnance.

Fig. 5.



Page 330.

Fig. 6.



Madras Artillery Depôt.

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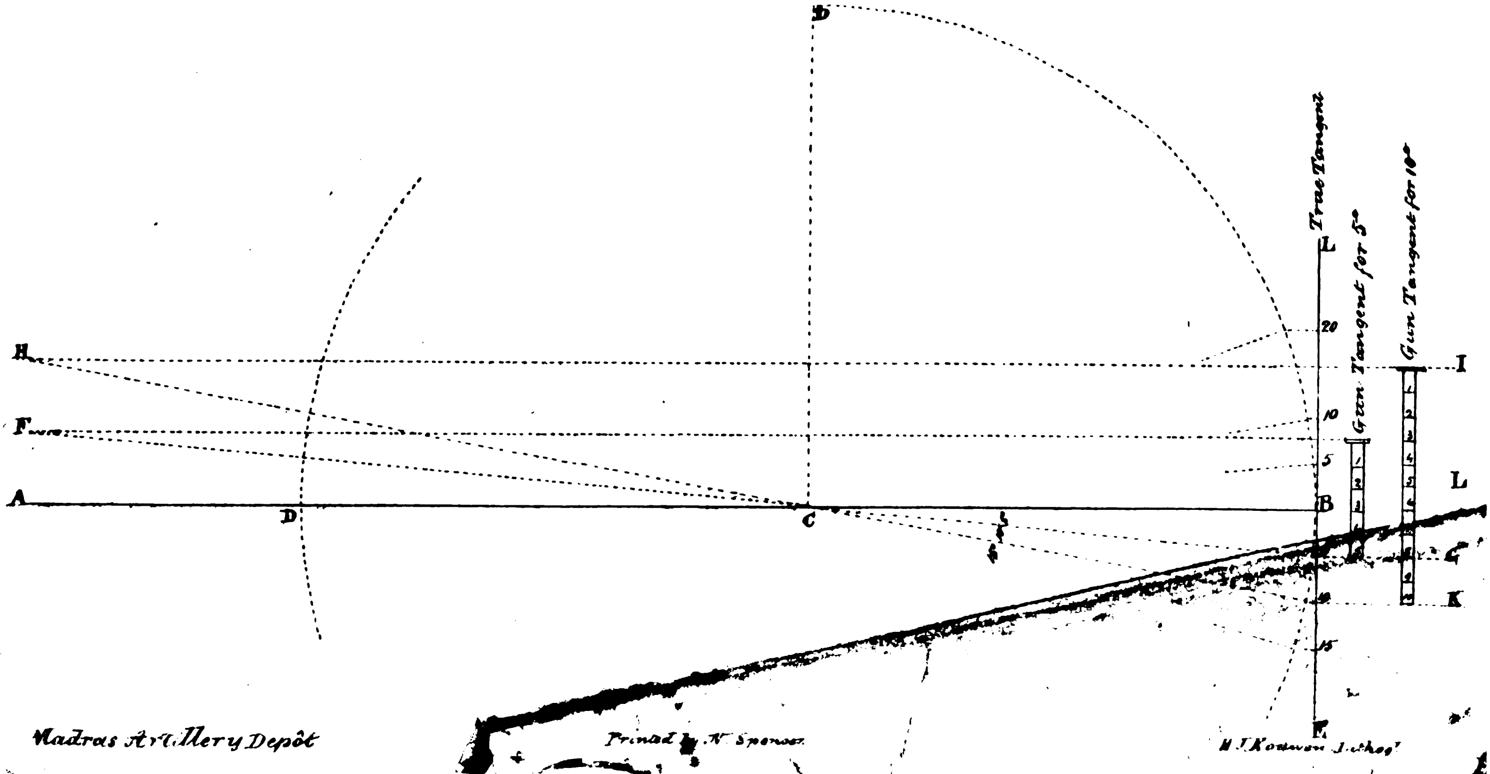
Miscellaneous

On Tangent Scales and method of fixing sights to Ordnance.—



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Ⅎ. 6.

Miscellaneous.

Russian Gun Carriage from the Sea of Azov.

FIG. 1.

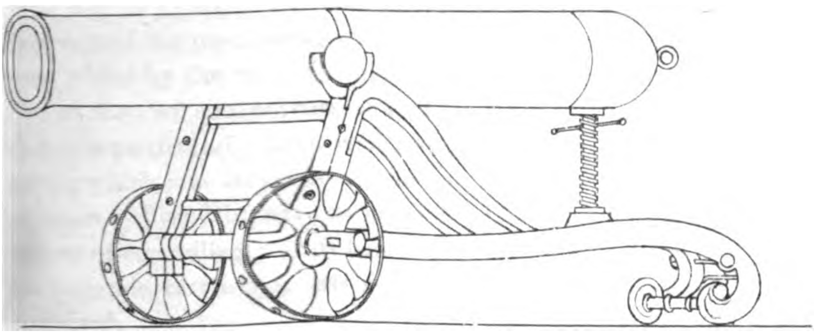


FIG. 2

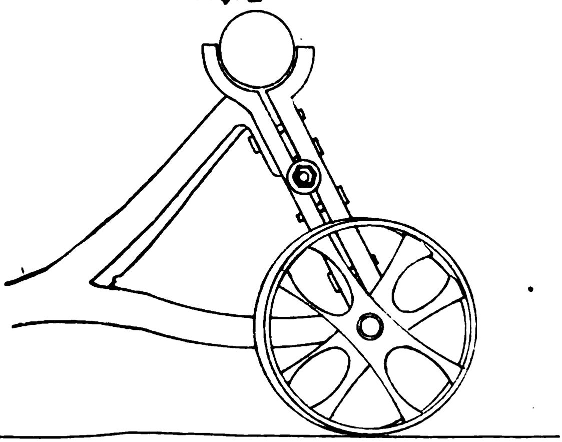


FIG. 3.

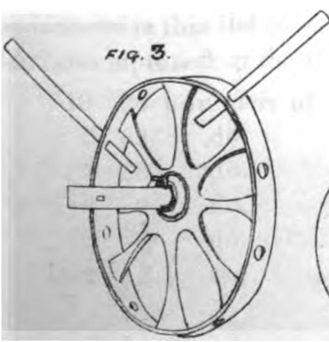
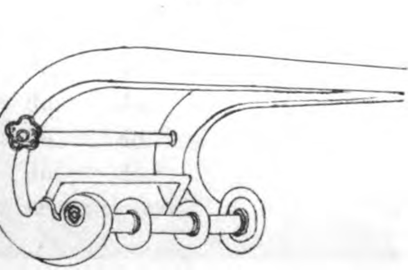


FIG. 4.



Madras Artil.y Depot

H. J. Kowen L.t

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several others. Thus a piece of iron cast in a metallic mould being more suddenly cooled than if cast in sand, is much harder, and has, besides, a very different texture. But whilst it is not improbable that the contact of the metallic mould may be equally or more favourable to a particular arrangement of the particles, such process will be so much the sooner stifled by the more sudden cooling. As to wrought iron, its fracture sometimes exhibits a crystalline texture, which is a particularly bad symptom of its strength, but one, perhaps, which may have some connection with a permanent expansion. Bismuth, and antimony are known to expand at the time of congealing; but how closely in this respect they may resemble cast iron, has not, as far as we know, been ascertained.

A few brief Remarks on the Russian Gun Carriages from the Sea of Azov. (Plate 21 Fig. 1.)

The Gun-wharf at Portsmouth has recently received the Russian cannon and the implements of war captured at Kertch and other ports in the Sea of Azov. They were brought home by the *Simoom* steam frigate; and as they lie about the arsenal they present a respectable trophy of war, and are suggestive of the struggle now pending between the allies and their gigantic opponent.

The subjoined is a correct list of these formidable instruments of destruction. It will be seen that they are all of Russian manufacture except the two small 3 pounders, as we have not included in this list those guns on the wharf of English make, also captured in the East:—

10	36	pounders of	Russian	make
2	68	do.	do.	do.
7	56	do.	do.	do.
6	9	do.	do.	do.
2	6	do.	do.	do.
2	3	do.	English	make.

Of course this instalment has nothing to do with the enormous booty captured at Sebastopol, but relates only to the guns taken in the Sea of Azov, by the allied fleets during the late brilliant expedition under the lamented Captain Lyons in the *Miranda*. Many of the 56 pounders, as well as the 36 pounders, bear evident marks of having been buried, and nearly the whole of them are spiked. They are well made, and some of them are ornamented with the imperial eagle, and all of them have upon the trunnions the name of the foundry where they were cast.

Our object, however, is not so much to draw attention to these guns, as to allude to a novel description of gun carriage, which was also captured in one of the forts in the Sea of Azov. Indeed, this Russian carriage is a masterpiece in its way, and presents so great a difference from any in use in our own service, as to arrest the attention of almost every visitor, and has induced us to hazard a few brief remarks to draw the attention of our engineers to its peculiar mode of construction, in the earnest desire that any advantages it may possess may not be lost sight of, but be applied to our own artillery.

We are the more induced to undertake this task from the conviction that seems to be gaining ground amongst military authorities, and in the navy also, that of all the implements of war now in use, not one is more likely, or indeed more capable of being improved than artillery. We can imagine a limit to the shattering powers of our infantry and cavalry. The first will, in all probability, be furnished with the Minié and the bayonet for years to come; and the last will be armed with a lance or a sabre according to the force to which he may belong.

That this is not the case with the artillery the greatest generals of modern times have acknowledged. Without going farther back than Frederick the Great, it can be shown how rapid has been the progress made in this particular arm.

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Napoleon and Wellington each in his own way turned this terrible instrument of war to account; and as it is impossible to say, or even to speculate upon the new forms which rockets and shells may issue from the great laboratory of science, there seems to be no limit to the destructive force which modern artillery may be invested with.

In an inquisitive age like the present this perfection may be attained sooner than expected, and, without indulging in the spirit of prophesy, we may, we think, safely predict, from past experience, that the day is not far distant when it will be proved that the art of winning battles will be based upon the art of manœuvring artillery, and which will consequently become the principal arm in modern warfare.

The few remarks we are about to make upon the gun-carriage so recently taken at Kertch, are intended to show that the Russian Czar has evidently felt the enormous power of an efficient artillery, and that he has studied the subject minutely. Let us therefore take a lesson and profit by it if we can.

Simplicity of design, coupled with lightness, strength, and *uniformity* of construction, seems to be the object aimed at in the contrivance of this carriage. The absence of these qualities, or at least the absence of uniformity, has always, and does now, impede the utility of the British Artillery. We suffer from a multiplicity of guns and carriages.

We seem to be always approaching perfection, never reaching it. *Our personel* is admirable, our *materiel* is excellent, but our gunners are often puzzled with the different description of gun they may be called upon to serve. A glance at the different pieces in use is enough to convince us how confusing they may be made under various circumstances. For instance, we have 12 pounder medium guns, 9 pounder ditto, heavy and light 6 pounders, 10 and 8 inch Howitzers, 32 and 24 pounder brass howitzers, 12 pounder ditto, and various other calibres. Every one of these guns differs in

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respect to the carriage; that is to say, they differ as to their total length, length of axle, breadth between wheels and diameter of wheel.

The enumeration of the above description of artillery is sufficient to give an idea of the complication of the English system of gun carriage, but to which must be added ammunition wagons and limbers, for each gun according to its particular nature and construction, together with spare carriage, and spare wheels, store carriage, and forge wagon and limber, &c.

It is not our intention to advocate any alteration in the system of our artillery either in forts or in the field, until experience has shown a necessity for a change, but it would seem that very great uniformity might be introduced into the service and confusion avoided, if a carriage could be so contrived as to be adapted to receive guns of different calibres. And that this Russian gun carriage has been constructed with this intention is probable, for although it is available in a fortress, from whence it was taken, yet it appears to be capable of being limbered up, and used in the field.

However, should this view of its uses be disputed, there can be no doubt that it can be adapted to receive almost any sized gun. To illustrate our remarks we have made a diagram or profile view of the framework of the carriage. (Plate 21 Fig. 2.) It will be observed that the trunnion of the gun is received into an expanding arm, composed of two pieces of wrought iron four inches square. It is obvious that by this contrivance the arm intended for the trunnion of the gun can be expanded or contracted at pleasure. All that is necessary to be done is to screw the moveable plates closer together, or to reverse the action and expand them, in order to adjust the arm for a larger or smaller gun. These moveable plates are not liable to injury, for they are firmly bound to the axle (which is very strong and also peculiarly contrived) by nuts and screws.

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That the intention of this carriage was to receive guns of different lengths is further evidenced by the construction of the elevating screw at the rear of the piece. This apparatus is fixed to a moveable iron case or box, which is so contrived that it can be made to slide up and down between the side frames of the rear of the carriage, and can be instantly arranged so as to correspond with the length and dimensions of any gun in the service.

The wheels also, like the carrirge, bear out the design of the contriver, as a description of their make will prove. They are made of iron, are nearly four inches broad at the tire, and two feet and a half in diameter. In the tire, at equal distances between the spokes, there are eight holes of two inches diameter each. The use of these holes seems to be for the introduction of a rod or lever, to assist in the rapid working of the piece. By this means a man would be able to exercise great power over the movements of a heavy gun, and render valuable assistance in addition to the ordinary machinery now in use for working heavy guns in difficult situations.

In the accompanying diagram (Plate 21. Fig 3,) it will be observed that the axle extends some distance beyond the width of the frame of the carriage; indeed, the axle presents a novel and perhaps useful hint to our Artillerist. From its great length it is evident that it is intended to receive a larger pair of wheels; and this is further proved by the fact, that there is an extra linchpin hole placed at that distance that allows sufficient space for another wheel to rotate upon that part of the axle, between the two linchpin holes.

In field operations it might often happen that a loftier pair of wheels would be desirable, and the construction of this carriage admits of a larger pair of wheels being adjusted without taking off the smaller ones; and, without going more into detail, it is evident from the design and formation of the other parts of the framework of this Russian gun carriage, that it is

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made to adapt itself to guns of different weights, calibres, and dimensions, and also that it might, on occasions of emergency be made serviceable in different operations, either as a fort gun carriage or in the field.

The trail of the carriage (Plate 21 Fig. 4,) differs materially from any thing we have ever seen in gun carriages before. It is not quite clear what is intended to be the use of the roller, unless it be to ease the shock of the recoil. A few practical hints, however, may be gathered from the formation of its parts, which assists in supporting the idea already advanced, that the carriage can be limbered up, and used in other positions than a fortress when required.

The whole appearance of the carriage is that of being too slight to bear the heavy gun now mounted upon it, which is not indeed a Russian gun, but one of English make, though captured from the Russians.* This gun was taken by Captain Lyons from the enemy's flag-ship in the sea of Azov, and is of great weight and calibre; yet there is no reason to suppose that the carriage is unequal to bear it, for it is very strong, the iron of which it is composed being wrought, and four inches square; and it appears to be scientifically arranged to bear the strain of a recoil. It also possesses an advantage in presenting a reduced size, and consequently being less liable to be injured or struck by shot, to which must be added that it is not likely to splinter, an advantage that ought not to be overlooked. In concluding these brief remarks, we cannot help alluding to

* In reference to this subject it may be observed that some difference of opinion exists respecting the place where many of these guns were cast. It was remarked by the *Times'* correspondent as a curious fact, that on some of the guns captured at Sebastopol, there appeared the Carron mark; and another talented writer, who signs himself "A Hertfordshire Incumbent," endeavours thus to explain the matter. He says, "These cannon, marked Carron, came from the works at Lugan, on the Donetz, which were established by an Englishman of the name of Gascoigne, who had been Superintendent at Carron, and probably the original moulds were copies from some which had been used there." His inference may be correct, but how can we explain the important fact, that the trunnions of the gun taken from the Russian admirals' flag-ship in the sea of Azov by Captain Lyons bear the initials of W. and Co., unless it is assumed that some English firm supplied them, or else that the initials were added to the guns voluntarily by the Russians themselves for some purpose not easily understood?—*Colburn's United Service Magazine for November* 1855.

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the observations made after the battles of the Alma, Inkermam, Balaklava, Tchernaya, &c., respecting the excellent practice of the Russian Artillery and its rapid movements, but more particularly to the astonishment manifested by the allies at the weight of metal, not only posted in difficult positions, but brought to bear in the field with terrible effect against them. Without attempting to explain these feats of arms, which task we leave to the pen of some future historian of the war to illustrate, we, in the mean time, merely suggest that this description of carriage, with its extra lofty wheels, extended axles, and great facility of leverage at the tire of the wheels, modified in a particular way to suit the peculiarities of field operations, may serve to show how some of these artillery exploits of the Russians were performed.

U. S. G.

Russian Gun Carriages taken in the sea of Azof.

The writer of this article does not appear to be an Artillery Officer nor a draughtsman, but as we have no better information we must make the best of what we have. The first plate, or figure, in page 365* represents a Russian Gun, (on its Carriage) complete—the thickness of metal being at the narrowest part of the gun, supposing the gun to be 4 inches calibre, one quarter of an inch! This is something like the proportions of a fowling piece, but of no Gun that ever I heard of—I measured the plate roughly, it may be a little more, or less, but the impossibility of such a Gun having ever been made, is evident at a glance.

The second figure* shows an "expanding Trunnion arm," an ingenious idea, of which something might be made. This I recommend to our young Officers who may hope to see the day when *wood* will be done away with, vegetable matter disused, I am fast losing hope of seeing it myself.

The third figure* shews a pair of wheels very different from

* Plate 21 "Artillery Records."

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those in figure 2, and handspikes put into little holes in the rim in a manner which could not possibly give any power, and figure 4* gives a most incomprehensible view, (as the author states) of the end of the trail.

P. Anstruther, Lieut. Col.

Lectures on the construction of Guns by Professor Olinthus Gregory, communicated by Lieut. Colonel P. Anstruther, C. B.

To

The Director of the Artillery Depôt of Instruction, St. Thomas' Mount.

Sir,—I have the honor to forward a copy of some "Lectures on the construction of Guns," which I recommend your publishing in our Artillery Records, and I beg further to recommend that they should be printed separately, as far as the numbering of pages and so forth is concerned, in order that any person possessing a complete copy may be induced to supply us with the latter portion which I regret to say is wanting in my manuscript.

The Lectures were delivered at Woolwich, by the very highly honored Professor Olinthus Gregory, and the only copy I have ever seen was that in the possession of my valued friend Lieut. Colonel Knowles, Royal Artillery, who served with us in China. I borrowed his copy and commenced transcribing it, I got tired of doing so and had the remainder written for me by a Gunner of my own Company, I have lost all his part of the transcript, and I returned the original to my friend.

If you will print the small portion I now send, and let me have 50 or 60 copies, I will forward them to some Officer of the Royal Artillery for distribution, in the hope that some one of the recipients may be able to find a complete copy and will enable me to publish it, or do so himself and furnish me with a copy.

I made during my late, very short, stay, in Europe several

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efforts to obtain a copy of these lectures but from some cause or other unsuccessfully.

I called upon Mr. Hutton Gregory, guessing from the name that he was the son of the Professor but he could not find a copy in his Father's papers, he kindly gave me an introduction to an Officer of the Royal Artillery whose name I have forgotten, and I went to Woolwich to try if a copy existed there, but without success.

Recognizing in Straith's book on Fortification and Artillery a Table similar to that contained in these Lectures, I wrote to Major Hector Straith, and to Captain Cook R. N. Professor of Fortification at Addiscombe to enquire for a copy but without success.

I venture to recommend that you should publish, even the fragment I send, not that I agree on all the theories therein stated, but as much of it is valuable even if wrong.

Your Obedient Servant.
(Signed.) P. ANSTRUTHER.

On the Shape and Dimensions of the Gun.

It will be granted that the bore should be cylindrical, and it is evident, that the length up to a certain point, contributes to the augmentation of the initial velocity with which the Ball quits the Gun, as well as to steadiness and uniformity of motion, and resulting range,—Indeed so far as relates to the increase of initial velocity, the longer the gun is the better.

The length is limited by practical considerations of facility of motion, and the space occupied by them, the latter consideration operating strongly on board ships, but so far as can be inferred from the most cautious reasoning, aided by the most accurate experiments, there can be no question that Guns much longer than any now used might be employed with great advantage as to velocity, were increased velocity required.

In Dr. Hutton's experiments, 4 Guns length in calibres

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14, 19, 28½ and 39¾ respectively, gave with charges equal to half the weight of the shot; velocities of 1431, 1552, 1787 and 1936 feet per second, and from the experiments of 1815-16, the results with 6 Pdrs. were these.—The calibers of each Gun was 3·668—the shot 3·55—windage constant=·118.—The Guns were short, medium, and long 6 Pdrs., lengths 4 feet 6 inches and 5 feet 7⅝ inches.

With 1½ lbs. of Powder, the initial velocities were :—

Short	1440
Medium	1452
Long	1497

With 2 lbs. of Powder, the velocities were :—

Short	1596
Medium	1632
Long	1748

With charge of 2 lbs., but stronger Powder, the velocities were :—

Short	1633
Medium	1633
Long	1785

Analogous results were furnished by 12 Pdrs. and 24 Pdrs. whose respective lengths were in the same ratio.

The general deduction from the whole of both Dr. Hutton's experiments, and those made since his time is that the velocity increases with the length, though the increase of velocity is small compared with the increase of length; the velocities being in a ratio somewhat less than that of the ½ roots of the length of bore, yet somewhat greater than that of ⅓ roots being nearly as $2\frac{5}{12}$.

Mortars were at first constructed of different calibres, figures and dimensions, according to the service for which they were designed—the largest was 20 inches calibre, the smallest (called Royal Mortars) 5½ inches. From the interior figure of the Mortars the elastic fluids generated in the chamber are dilated on passing into the chase but its pressure against the shell is still sufficient to give it a proper velocity, unless

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the charge be too small; as is seen in Carronades and Howitzers, which in respect to their interior figures may be compared to Mortars with Cylindrical Chambers.

Chambers have been constructed of different shapes and sizes, but altho' Belidor, Muller, and others have said much as to their several advantages and disadvantages, I am not aware that their peculiar properties have ever received the complete investigation which they merit. In Belidor's time, Chambers were made of 4 different shapes, cylindrical, hemispherical, conical, and concave or bottled, and afterwards parabolic was added by Count de Lippe Bucheburg; of these the hemispherical and conical are considered the best.

A recent improvement upon what is called the Gomer principle is strongly recommended. In this the bottom of the Chamber is spherical, connected with the cylindrical part of the Mortar or Carronade by a frustrum of a cone gradually enlarging till its diameter is equal to that of the cylinder. Vide Sir H. Douglas Vol. 2; one of the obvious advantages of this shape of the interior of the Mortar or Carronade, is, that it allows the shell or ball to be brought into complete contact with the sides of the conical entrance of the Chamber, thus taking away all windage at the commencement of the explosion, and subjecting the projectile to the entire force of the ignited Gunpowder.

With regard to the thickness of metal in guns, there are obviously two extremes to be avoided, the one is making them too thin and light, the other is making them too strong and heavy. The metal proportionably distributed through the whole of the piece, ought to be capable of resisting the force which at each point tends to burst it, and of such a weight and mass as to recoil, but to a very small distance, after the shot has quitted it, and therefore not to prevent *on that account* any disturbance to the regularity of the ball's motion. No abstract and general rule can be laid down for

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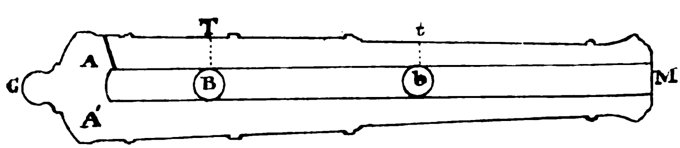
the thickness of metal in guns, Brass, or Iron, since several physical considerations are involved in the investigation.

It was proposed by some foreign Engineers to ascertion the thickness proper to resist the pressure of the fluid in a Gun of given calibre, after this manner. Having it strongly reinforced, they fired it several times with the same charge, they then thinned the metal and fired it again with the same charge, and then successively diminishing the thickness, till it was so reduced that the piece burst at once in every part of its length.

This, however, it is evident must be a very tedious process, and after all, such experiments cannot be conclusive in all cases, though made with the utmost accuracy, because of the varieties in the density, and other circumstances affecting the general mass, for which no *correct* allowance can be made. It seems better therefore to adjust the exterior and interior dimensions of pieces of Artillery from the result of *general* experience; to construct them accordingly, and then subject them to the established mode of proof.

Theoretical considerations, however, though stated in the most popular way, will serve to shew that the metal should be thickest at the breech and may then proceed by a gradual diminution to the muzzle.

First it is evident that the thickness of the breech at the bottom of the bore A A′ and the cascable C must be such as shall be capable of resisting, without rupture, the whole explosive energy of the powder, even if recoil were checked, as it often is.



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With regard to the relative lateral thickness at other places, as at B b, let us reflect a little upon the forces which act simultaneously. Suppose the Ball at B—There is first the elastic force of the Gunpowder occupying A B, exerting itself in all directions.—2d. the inertia of the Ball, which resists motion, and which is equivalent to its weight into its velocity. This latter force being opposed by the former, causes it for a moment to accumulate, (as a rapid stream against any obstacles to its course) thus tending to produce rupture in the direction B T.—3dly. The resistance of the air between B and the Muzzle of the piece, which cannot vary (see fig. above.) The Tendency to break the thickness at B T, is elasticity in A B, (resistance of air at B to the motion of elastic fluid + the momentum of B) the same takes place at b, but the elasticity of the powder is less at b, than at B, in ratio $\frac{Ab}{AB}$; the momentum of Ball is much greater at b, than B ; and the resistance of air must be the same at both places, because though the ball proceeds from B to b, with augmented velocity, the elastic fluid moves slower and slower, the impression of the whole force being only momentary upon any point of the bore ; altogether the tendency to rupture is less and less from Breech to muzzle, except actually *at* the muzzle, where the elastic fluid tends to escape in all directions and requires a greater thickness.

The Ball cannot make way for the expansive fluid generated by the powder, so rapidly as the fluid would naturally move, and it therefore resists by its retarding force— The ignited powder moves (unimpeded) at the rate of 5000 feet per second (Hutton 2. 362) but air can only yield to it with the velocity due to the height of the homogenous atmosphere, or about 1340 feet per second ; the air therefore becomes compressed, and thus tends to check the course of the powder. It is from the combined effect of these *three* forces, that the piece runs the risk of bursting ;— now Gun metal will bear without permanent alteration a

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pressúre of about 18,000 lbs. upon a square inch, and will not yield to a pressure exerted instantaneously, unless it exceeds 93,000 (?) lbs., more than three times the initial pressure of inflamed Gunpowder :—But as the Ball passes even out of a long 24 Pdr. in less than 100 of a second, and a space occupying a square inch in the side of the bore is not exposed to the Maximum pressure, the $\frac{1}{10000}$ of a second, it has not time to overcome the strong cohesive attraction of the particles of the Gun metal, if the Gun be duly constructed, and therefore no rupture takes place.

Supposing the Ball moved from B to b, the velocity of the elastic fluid is less than at B, in the ratio of A B, to A b, consequently the opposed compression of the air is less at b, than at B, and although the inertia of the Ball is greater at b, than at B, since it is now moving with a greater velocity, yet the difference on this account is by no means so great as on that of the air's diminished resistance ; so that on the whole, the force operating to produce rupture is less at b, than at B, and less thickness b t, of metal is requisite.

Thus it appears the metal may with safety be made thinner and thinner from Breech to Muzzle, but immediately *at* the muzzle, the elastice fluid has a tendency to escape in all directions, but is impeded by the Ball causing it to react upon the lips, so to say, of the piece, and suggests the expediency of giving a little additional thickness there.

From all this the following conclusions may be drawn.

1. That long guns ought to be cast of harder metal, and more reinforced from the middle of the chase to the muzzle, as, in that part, guns of this nature are most exposed to blows from the shot.

2. That Guns intended to bear large charges should be reinforced as much as Guns of common length, since in the case specified they have equal force to resist.

3 If the medium charge be the largest ever used for these

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Guns and rammed in the usual manner, the lateral thickness about the vent need not exceed $\frac{7}{8}$ of the calibre, the other thicknesses diminishing in the usual proportions.

4. When short Guns are only intended for firing case shot without wadding, the internal pressures being much diminished the calibres may be increased, and the thickness proportionably diminished.

We may now proceed to consider.

4thly. The effects of external configuration. Instead, for example, of the usual shape with a gradual diminution of thickness from the breech outwards, suppose it were proposed to construct Guns in shape of a conic frustrum with the thicker end foremost, would any advantage result?

None. The disadvantages would be numerous. If the metal were only sufficiently thick at the muzzle it would be too weak at the breech and there burst. If thick enough about the vent it would be too thick at muzzle, and double the requisite weight of metal with trunnions too far forward, the whole Gun unwieldy and bad.

But suppose the Gun, a conic frustrum, thicker at the breech, and much thicker than in the usual construction, would advantage result? Quite the contrary—such construction has been strongly recommended, but is exceedingly defective and unscientific. The truth is, and it should be permanently impressed upon our minds, that the veloci;y of the ball depends upon the size, shape and length of the bore, and not upon external configuration, which latter however may modify the motion of the projectile as to direction and steadiness, and if great care be not taken will so modify it as to do great harm. In forms of the external configuration of the conic frustrum considerably thicker at the breech, this argument has been used. A hammer in shape of a conic frustrum falling through a given height and striking a ball, will give it a greater velocity with the smaller end than if

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the blow were given with the greater end of the same hammer, therefore a Gun should be a conic frustrum with its smallest end foremost. I should insult you were I to waste time in proving to you, that there is no connexion between the premises and the conclusion. That a greater thickness of metal at the breech of a Gun than is absolutely necessary to prevent its bursting there, can have no tendency to increase the initial velocity of a ball propelled from it with a given charge is obvious, both from theoretical considerations and the result of experiments.

If any such tendency to increare the initial velocity were occasioned by augmentation of metal at the breech, and consequent change of exterior figure there, it could only be, because the vis inertiæ of that increased metal would tend to keep the Gun more nearly quiescent during the passage of the ball along the bore, than it would be with a smaller quantity of metal there, and if that were the case, a fortiori, it would follow that keeping the Gun entirely quiescent would still further augment the initial velocity, which is contrary to experience. Some of the experiments made by Sir T. Blomefield and Hutton were directed to this very point, and it was proved indubitably, that while the strength of the powder and bore of Gun were the same, no change followed the initial velocity, from varying the weight of the Gun, increasing the metal about the trunnions, about the breech and cascable, or causing the Gun to vibrate freely as a pendulum during discharge, by diminishing recoil, or finally by preventing it altogether.

Mr. Robins also lays down, that "Cylinders of equal bores and equal lengths with equal charges of powder and balls, will discharge their shot with equal velocity," and adds "we must insist on the truth of the maxim how opposite soever it may appear to long established prepossessions." Giving much greater thickness to the matter between the trunnions and the breech, has then no positive advantage.

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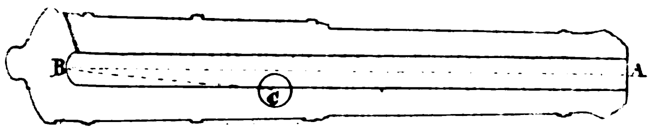
Let us now enquire into its positive *dis*advantages. In order that the recoil may be steady it would be necessary that the common axis of the trunnions should exactly intersect the axis of the Gun, instead of passing below it, and that the Gun should recede freely from its position at the first moment of explosion, in a direction exactly opposite to that in which the ball commences its motion.

The force which tends to produce unsteadiness of recoil, is to the force of the inflamed gunpowder on the breech of the Gun, as the sine of the angle made by the axis of the piece, and a line drawn from the centre of the trunnions to the centre of the breech to radius, that is, as the sine of the angle C B A, to radius.



Now it is evident according to the established practice of placing the central axis of the trunnions below the axis of the piece, and the farther necessary limit of only placing the trunnions a *little* before the centre of gravity of the piece, the angle C B A, which increases with the proximity of the trunnions to the breech must increase as more thickness is accumulated in that part of the Gun, because such a construction throws the centre of gravity C, and of course the trunnion nearer the breech. The force which augments with the angle C B A, tends to make the breech of the Gun move

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downwards and the muzzle upwards round the trunnions as an axis of rotation, and in such manner that the angular velocity about C as a centre, varies directly as the sine of the angle A B C, into the distance B C, and inversely as the weight of the Gun into the square of that distance.

That is angular Veloc. $\propto \frac{C\ B\ sin.\ A\ B\ C.}{wt.\ gun \times C\ B^2}$

such tendency to angular velocity will first cause the trunnions to rise as far as they have play, and then both Gun and Carriage to turn upon the posterior edge of such carriage after the manner of a hammer lever. Thus a most irregular jolting motion will be produced, increased in proportion to the shortness of the Gun and continued nearly to the end of the recoil. It will however be most violent during the time the ball is in the cylinder; the ball therefore partakes of the irregularities of the Gun itself, so that the utmost deviation from uniformity of range may be expected, and are indeed found to take place whenever Guns of this conical exterior are employed.

Comparing a long 24	trunnions and breech	41	inches distance,	wt.	50	cwt.
with a short conical 24	do	do.	29	do.	do.	do. 40½	do.

the disturbing forces are found to be 43 : 18 that is the tendency to unsteady recoil in the long Gun is only about $\frac{3}{7}$ that of the short, and, therefore, to render the other equally manageable, especially aboard-ship, it must be fired with less than half the customary charge of powder, a measure which would of course diminish its efficiency as a weapon of war in about the same ratio. Similar observations will apply iu all analogous cases.

5thly. I propose to speak of the velocities with which balls are projected by equal charges of powder, from pieces of the *same weight* and calibre, but different lengths. Much of what might here be mentioned, I have already anticipated under another branch of enquiry.

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I shall therefore simply present you with a table of medium results.

Charges: weight of Ball, or	Initial Velocities. Lengths of bore in Calibres.				
	12	17	20	30	40
·125 $\frac{1}{8}$	684	982	1000	1040	1080
·25 $\frac{1}{4}$	1280	1380	1400	1460	1500
·375 $\frac{3}{8}$	1498	1592	1610	1671	1708
·5 $\frac{1}{2}$	1732	1825	1840	1694	1902
·75 $\frac{3}{4}$	2196	2280	2300	——	——
1 1	2420	——	2600	——	——

The numbers thus exhibited amply confirm the laws which I have before mentioned, and shew that though the velocities increase so long as additional length is given to the bore, yet after its length increases beyond 20 Calibres, the augmentation to the velocity is extremely small compared with the addition to the length. Thus with a charge $\frac{1}{4}$ the weight of the ball augmenting the charge from 20 to 40 calibres only adds $\frac{1}{14}$ to the initial velocity. That adding to the length should occasion increased velocity is the joint effect of two causes. 1st.—The force of the ignited powder acts longer upon the ball and therefore communicates a greater velocity. 2ndly.—In short Guns no small portion of the powder is carried out of the muzzle unignited, even in the longest Guns *some* powder is thrown out unignited, but the portion thus lost in projectile effect is less than in a short Gun, whence results an augmentation of initial velocity. The facts and principles thus adduced, blended with the observations of practical men, will enable you to estimate, for example, the value of Carronades compared with long Guns. At close quarters carronades are formidable, but at long ranges they are no match for long Guns even of smaller calibre. Carronades fired at P B range about = 150 yards varying with the size of the ball and its proportionate charge from 660 to 750 yds. Whereas long 24 Pdrs. at an elevation of 3° would

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with the charges of 4, 6, and 8 lbs give ranges of 900, 1200, and 1300 yds. and 32 and 42 Pdrs. still further. Hence appear the disadvantages under which a vessel fitted with carronades only, would meet a vessel even of inferior rate, if mounting long Guns. Thus Sir James Yeo, and Captain Barclay, Canada Lakes, state "Enemy fired, at long ranges, "I having only 6 Guns in the fleet that could reach the "enemy. Not a carronade was fired."

6th. We now come to consider the velocities with different charges, weight and length being the same. This is an interesting consideration, which has not met with a corresponding attention. Robins and Euler theorized upon it, but the earliest experiments which I am acquainted with, directed to this point, were made in the year 1775 by the "Military Society" then recently formed among the Artillery Officers, June 12th 1775; they fired 3 shot, wt. 18½ oz. with 2 ozs. of powder, and 3 others with 4 ozs; the mean *initial* velocities were 735 and 1023 feet being nearly as $1 : \sqrt{2}$:— again 20th July several shot were fired each 28½ oz. Thus

Charge.	Mean velocity.	Nearly as	
2 –	615	$1 : \sqrt{2}$	Results high-
4 –	877	$1{\cdot}426 : \sqrt{4}$	ly satisfactory
8 –	1166	$1{\cdot}9 : \sqrt{8}$	& uniform.

Subsequent experiments by Sir Thomas Blomefield and Dr. Hutton amply confirmed this law, viz. that the velocity is directly as the square root of the weight of powder, till it becomes about half the weight of the shot when the law fails. Similar results were furnished by the experiments of 1816 and 1815. The general deduction is, that the velocities given to different balls by different charges (Guns being similar) and windage proportional are as the square roots of the weights of the powder *directly* and as the square roots of the weight of the balls *inversely*. Good powder, such as now used, gives as a medium, with a charge of ⅓ the shot's weight

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an initial velocity of 1600 feet, (may now be taken at 1700), employing therefore B and C, to denote ball and charge, the Formula

$$v = 1600\sqrt{\frac{3\,C.}{B.}}$$

will express the mean velocity. Short Guns will give a velocity a little below, long Guns a little above, this estimate. By increasing the quantity of the charge continually, it has been found that the velocities continue to increase till they arrive at a certain degree different in each Gun. After which they constantly decreased again, till the bore was quite filled with the charges. When the length of the Gun is about 15 calibres, a charge which occupies $\frac{3}{10}$ of that length gives the maximum velocity. A length of 20 calibres, $\frac{1}{4}$ of its length gives the maximum. A Gun of 30 calibres long $\frac{3}{16}$ and so on.

Length of piece in calibres		Length of charge in calibres to give maximum velocity.
5	—	1·47
10	—	2·64
15	—	3·60
20	—	4·42
25	—	5·12
30	—	5·73
35	—	6·27
40	—	6·75

The theory, as exhibited in prob. 18 of the Practical Exercises at the end of vol. 2 course—gives the results for a charge due to the maximum velocity which accord very nearly with those I have just specified, you will soon see however that the velocities thus obtained are too great to be of any practical utility, by reason of the enormous resistance which balls moving with such extreme rapidity experience from the air.

7th. The effect of different degrees of windage, both as to velocity and direction of propulsion. Every one must

have observed that the motions of balls and shells are subject to very great irregularities, and these arise partly from variety in the strength of the powder, either of its original manufacture, or from exposure to moisture; partly from changes in the density of the air, often changing the air's resistance as much as $\frac{1}{10}$ of its entire value; partly from the effect of "*windage;*" partly from the rotation of the ball in the Gun, and partly from the great resistance which a projectile meets in its flight. If the ball fitted the bore of the Gun with perfect accuracy, its centre would coincide with the axis of the Gun, and the direction of the ball will be that of the Gun itself. But such accuracy has never yet been attained in common practice. The difference between the diameter of the ball and the bore is called windage, and until recently this was often allowed to be as much as $\frac{1}{4}$ of an inch, nay, sometimes $\frac{4}{10}$!—If the ball in its passage along the Gun always rubbed against the lower part of the bore it would be discharged a little lower than the direction of the Gun, and this, therefore, though an error, would cease to have the consequences of an error, as it would be known and might be accurately allowed for. As however the ball may on account of its windage rub against different parts of the bore at top, bottom or sides, at the moment of its quitting the Gun, its initial direction will have corresponding irregularities and this will greatly affect the range. Thus Robins speaks of two shot fired successively from the same piece, charge and elevation equal, with ranges of 2300 and 3000; and other shot gave a difference of direction on the horizontal plane of 15°, similar irregularities are constantly observed up to the present day. The rotary motion of the ball in the Gun and after its quitting the piece has very considerable effect, and this rotation must be much increased by large windage.—To familiarize to yourselves the effects of this motion, observe boys playing at marbles, a *screw* at Billiards, or a *spin* of a hoop.—Likewise if shot either have little

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flatnesses or indentures on their surface, or any of their parts of unequal density (the latter always the case) the friction from the bore gives them rotation, causing irregularity of range both as to direction and distance, independently of all other considerations.

Besides the prejudicial effects of great windage in producing great irregularities in the range, there is the further disadvantage of a loss of the explosive force, escaping unused. If the windage is $\frac{1}{10}$ of the shot's diameter, the section of shot and section of cylinder will be 100 and 121, and $\frac{1}{6}$ of the powder is wasted. A windage of $\frac{1}{20}$ (till lately the fixed allowance) would give sections of 400 and 441—losing $\frac{1}{11}$ of the whole quantity, besides the effect of friction, and rotation. The efficacious quantity of powder being thus reduced, the velocity of the ball which $\propto \sqrt{wt.}$ of powder will be diminished too. Conformably with this, Dr. Hutton found that in many cases from $\frac{1}{8}$ to $\frac{1}{4}$ of the effect was lost by windage, and sometimes as much as $\frac{1}{2}$! Two remedies have been proposed for the removal of these irregularities and defects. One is the substitution of cylindric shot with spherical or spheroidal ends for spherical shot. This was first proposed by the Military Society of which I have before spoken in 1775, but they did not pursue the idea far; an account of their proceedings can be seen under the head "Gunnery" in Captain Smith's Military Memo.

In 1782 Mr. Anderson, Professor of Natural Philosophy, Glasgow University, proposed a similar shape of ball, and made several experiments assisted by the Gunner at Dumbarton Castle.—The Gun was an iron 6 Pdr. of 8 cwt. 90 lbs; the carriage 1 cwt. 30 lbs.—The spherical balls weighed 6 lbs. each—the other balls, called spheroidal, had two hemispherical ends with a cylinder between them weighing altogether 12 lbs.—Barometer was 29·8. No wind: Thermometer 58. Temperature of Gun immediately after each discharge 64°, loading, ramming and pointing alike.

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	Ball 6 lbs. Range.	Deviation.	Spheroidal 12 lbs. Range.	Deviation.
	2592—Yds.	56 S.	3210—Yds	45 S.
At elevation 15° charge 4 lbs.....	2669—	92 N.	3290—	29 N.
	2521—	49 S.	3250—	14 N.
At elevation 15° charge 3 lbs. to	2246—	90 S.	2694—	10½ S.
the Ball and 2 lbs. to	2959—	36½ S.	2710—	21 S.
the spheroid.	2356—	34 S.	2699—	11 N.

From hence Mr. Anderson deduces ;—1st. the range of the spheroid is greater than that of the ball with the same charge, it will therefore have an advantage over it on account of the greater distance to which it will range.—2d. its deviation from a mean, both in longitudinal and lateral direction is less than the spherical ball, therefore it will carry with more certainty—3d. Two pounds of powder give a range to the spheroid which is equal to the range of the ball with 3 lbs.—so that $\frac{1}{3}$ of the powder will be saved by using these spheroids. The momentum of the spheroid at the end of its range is double that of the ball, fired from the same Gun with less charge. Consequently as far as these experiments can be relied on, the power of Artillery ought to be doubled by a similar process—a similar construction of oblong shot, and shells has been recently proposed by General Millar. I have not yet seen an accurate register of the trials of these against other balls and shells, several natures of oblong shells more or less cylindrical with flattened ends and hemispherical ends have been tried. Those which had the cylindrical part equal to $\frac{1}{3}$ of the diameter succeeded perfectly, ranging far and steadily, and on the whole it is highly probable that shot or shell thus constructed, would much diminish the injurious effects of undue windage.

But the most obvious mode is to diminish the windage itself; more windage than is absolutely necessary has been allowed, partly on account of the real or supposed irregularities in the size of balls of equal weight, partly because of their expansion by a white heat. But by due assortment,

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the former irregularity may be reduced within very narrow limits, and the expansion of shot at white heat is only about $\frac{1}{77}$ of the diameter of a 24 Pdr., $\frac{1}{76}$ for the 16 Pdr., and $\frac{1}{82}$ for the 6 Pdr. The windage therefore so far as these are concerned may be safely reduced. Experiments on the velocities of balls fired from the same piece with different windages were tried by General Millar, Colonel Griffiths and myself in 1817. They related to 6, 9 and 12 Pdrs. the velocities were ascertained by a large Ballistic Pendulum—weighing more than 700 lbs. I shall exhibit a table of results furnished by the 12 Pdr., weight 2025 lbs. (18 cwt. 0 qr. 9 lbs.) length 6 feet 2·25 inch, calibre 4·62 inch.

No.	Weight of Shot.	Diam. of Shot.	Windage.	Charge.	Velocity.
1	12 lbs. 12 oz. 0 drs.	4·545	0·075	3-5-6	1548 feet.
2	12 — 12 — 7	4·54	0·080	„	1537
3	12 — 11 — 0	4·545	0·075	„	1583
4	12 — 10 — 0	4·54	0·08	„	1507
5	11 — 11 — 8	4·42	0·2	4-0-0	1572
6	11 — 10 — 4	4·418	0·202	„	1537
7	11 — 12 — 1	4·418	0·202	„	1563
8	11 — 12 — 1	4·418	0·202	„	1529

Hence it is evident, that a velocity corresponding to a windage of ·075 or $\frac{3}{40}$ of an inch is at mean (1545) very nearly equal to that obtained when the windage was ·2 or $\frac{8}{40}$, though in the former the charge was less by $\frac{1}{6}$ part than in the latter. Thus it is manifest that a saving of 1 lb. of powder in every 6 would result from diminution of windage, and if it were reduced still further, still greater advantage would accrue—a great collateral benefit has already followed from the recent correction of windage. It was at first apprehended that the increased effects arising from the additional weight of shot and diminished windage would injure brass Guns, but the results, as some few anticipated, shew the reverse. With less windage, the balls quit the Guns without striking first on one side, then on the other as formerly, injuring the Gun less, and this has been so well ascertained that it is proposed to abandon the wooden bottoms, fixed to save the

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cylinder, and substitute the paper ends taken off the ends of the cartridges.

8th. The effect, if any, of different positions of the vent.

9th. The resistance of the air and other causes of deviation from the simple parabolic theory of projectiles.

When bodies of uniform regular structure are projected in free space, and subjected only to the joint influence of the projectile force and that of gravity, the path described is either a right line or a parabola, according as the original direction is vertical or horizontal. This was explained when we considered "Dynamics." But when bodies move through liquids and fluids, the resistance to which they are subjected in their course, considerably modifies the *velocity*, and in many cases the *direction* of the motion, so as to make the path of the projectile altogether different from that which would be traversed in free space. Hence, to understand Gunnery fully, it is necessary to attend to the nature and magnitude of the resistance of fluids, and especially of the air. The resistance which a body suffers from the fluid medium, depends on the velocity, form and magnitude of the body, and on the inertia and tenacity of the fluid. For fluids resist the motion of bodies through them. 1—by the inertia of the particles;—2—by their tenacity, i. e. the adhesion of those particles;—3—by the friction of the body against the particles of the fluid. In perfect fluids, the latter causes of resistance are very inconsiderable, and therefore are not taken into the account, but the former is always very considerable and obtains equally in the most perfect as in the most imperfect fluids. And that the resistance varies with the velocity, shape and magnitude of the moving body is sufficiently obvious.

We must carefully distinguish between resistance and retardation; resistance is the quantity of motion, retardation

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the quantity of velocity, which is lost, therefore the retardations are as the resistances, applied to the quantity of matter, and in the same body resistance and retardation are proportional.

To determine the force of fluids in motion, or the resistance of fluids against bodies moving in them.

In fluids uniformly tenacious, the resistance is as the velocity with which the body moves. For since the cohesion of the particles of the fluid is always the same in the same space, whatever the velocity, the resistance from this cohesion will be as the space described in a given time, i. e. as the velocity.

2, In a fluid whose particles move freely without disturbing each others motions and which flows in behind as fast as a plain body moves forward, so that the pressure is the same in every part of the body, as if the body were at rest, the resistance will be as the density of the fluid.

3. On the same hypothesis the resistance will be as the square of the velocity. For the resistance must vary as the number of particles which strike the plane in a given time, multiplied into the force of each against the plane, and both the number and force is as the velocity, consequently the resistance is as the square of the velocity.

This proof supposes that after a body strikes a particle, the action of that particle entirely ceases, whereas the particles after they are struck must necessarily diverge and cut upon the particles behind them, thus causing some difference between theory and experiment.

This hypothesis however on account of its simplicity is generally retained, and corrected afterwards by deductions from actual experiments. The ratio of the square of the velocity may be otherwise derived ; thus :—

It is evident that the resistance to a plane moving perpendicularly through an infinite fluid, at rest, is equal to the pres-

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sure or force of the fluid on the plane at rest, and the fluid moving with the same velocity in the contrary direction to that of the plane in the former case. But the force of the fluid in motion must be equal to the weight or pressure which generates that motion, which is known to be equal to the weight or pressure of a cohesion of the fluid, whose base is equal to the plane and its altitude equal to the height from which a body must fall by the force of gravity, to acquire the velocity of the fluid, and that altitude is for the sake of brevity called the altitude due to the velocity. So that if a denote the area of the plane, v the velocity, and n the specific gravity of the fluid. The altitude due to the velocity v being $\frac{v^2}{2g}$ the whole resistance or motive force m, will be $a \times n \times \frac{v^2}{2g} = \frac{a\,n\,v^2}{2g}$; g being $32\frac{1}{6}$ feet.

If the direction of the motion instead of being perpendicular to the plane as above supposed, be inclined to it at any angle, then the resistance to the plane in the direction of motion assigned above will be diminished in the triplicate ratio of radius to the sine of the angle of inclination, or in the ratio of 1 to s^3 where s is the sine of the angle of inclination. Combining these principles with the Geometrical ones which appertain to the shape of any particular body supposed to move in a fluid formulæ expressive of the magnitude of the resistance, are easily obtained, and some of them may be found in the 2d vol. of the course. Thus $\frac{x\,n\,v^2\,d^2}{16\,g}$ = the resistance on a globe, and $\frac{x\,n\,v^2\,d^2}{8\,g}$, that on a cylinder moving end foremost with velocity v, n denoting density of medium, $g=32\frac{1}{6}$ feet, d diameter of ball, $x=3{\cdot}1416$. Hence it would follow, that the resistance to a sphere is equal to half the direct resistance to a great circle of N, or to a cylinder of the same diameter. When motion is slow in water the fluid may be conceived to be nearly of that nature which Newton supposes, yet the resistances are

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almost as coincident with theory as when the motion is in air; Thus M. Borda found the resistance of a sphere moving in water to be to that of its greatest circle as 1 : 2·508 and in air as 1 : 2·45.

The experiments of Dr. Hutton give the resistance as 1 : $2\frac{1}{3}$ at a mean.

The reason that experiments give the ratio of the resistances greater than 2 : 1 seems to be this:—in theory it is supposed that the action of every particle of the fluid ceases the instant it makes its impact on the solid, but this is not actually the case, as we have before observed, and since the particles after their impact on the sphere, slide along the curved surface, and hence escape with more facility than along the face of the cylinder, the error will be greater in the cylinder, that is, the greater resistance will exceed the theory more than the less. It is also to be observed, that the difference between the resistances of the globe and cylinder in water is greater than in air, which is directly contrary to what might be inferred from Newton's reasoning, which supposes them equal in a continuous fluid, but in the ratio of 1 : 2, in a rare fluid.

The greatest velocity that a globe will acquire by descending in a fluid by means of its relative weight in the fluid, will be found by making the resisting force equal to that weight. For when the velocity has arrived at such a degree that the resisting force is equal to the weight that urges it, it will increase no longer, and the globe will thenceforward descend with that velocity uniformly. Now N, and n, being the specific gravities of globe and fluid; $N-n$ will be the relative gravity of the globe in the fluid, and therefore $w = \frac{1}{6}\, x d^3 (N-n)$ is the weight by which it is urged, also $m = \frac{x n v^2 d^2}{16 g}$, is the resistance, consequently $\frac{x n v^2 d^2}{16 g} = \frac{1}{6} x d^3 (N-n)$ when the velocity becomes uniform, from

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which equation is found $v=\sqrt{\frac{2g\frac{4}{3}d(N-n)}{n}}$ for the said uniform or greatest velocity. You will ere long perceive some uses to which this theory may be applied.

The investigation of resistances, taken in all its generality, is by no means suited to popular exhibition in a lecture, but so much of it as relates to *Military* projectiles may be tolerably understood, without my drawing you very far into minutiæ. Here the enquiry is restricted to the motion of spheres whether solid or hollow, in the air, and the resulting resistance—Two general methods have been used for its determination, the one when the velocities are under 300 feet per second, the other when they exceed 300 feet per second.

The first is effected by means of a Whirling Machine made by Elliott for Mr. Robins in 1745, which Robins used in that year, and 1746, and 40 years afterwards Dr. Hutton used the same identical instrument—Diameter of barrel 2·06 inches—length of arm 49·5—diameter of original globe 4·5= that of a 12 Pdr.—Circumference described by centre of globe 331·38 inch: 27·62 feet made to revolve by the action of a weight.

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On the subject of Tangent Scales to Pieces of Ordnance, communicated by Lieutenant Colonel J. W. Croggan.

To

The Director of the Artillery Depôt,
Saint Thomas' Mount.

Sir,

I beg leave to submit the accompanying Paper and Diagrams on the subject of Tangent Scales to pieces of ordnance, which will I hope be found worthy of consideration.

(Signed) J. W. Croggan, Lieut. Col.,
Artillery.

Kamptee,
28th April 1856.

Tangent Scales.

The tangent scale of a gun should be constructed strictly on the principle of the tangent of an arc, viz. "it is a line "touching the curve at one extremity of that arc, and con-"tinued from thence to meet a line drawn from the centre "through the other extremity, which line is called the secant "of the same arc," (fig. 1 Plate 22.)

Thus AE is the tangent, and CE the secant of the arc AB.

Any rules that may have been laid down on the supposition of the line AD, or any other quantity being the tangent must therefore be incorrect.

Each gun should be furnished with a tangent scale made expressly for it; the lines marked on the scale for 1, 2, 3, 4 &c. to 10 or more degrees should not be equal divisions, as the differences between these lines increase as the angle becomes greater, that is, the difference between the lines denoting the 9th and 10th degrees is greater than that between the 1st and 2d degrees.

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The following extracts from a table of natural tangents are given in elucidation of the subject, the radius in all such tables being one.

Degree.	Natural tangent.	Difference of tangents for each degree.	Difference in inches suitable to a 6 pounder gun 60 inches in length.
1	·017455		
		·017466	1·04796
2	·034921		
		·017487	1·04922
3	·052408		
		·017519	1·05114
4	·069927		
		·017562	1·05372
5	·087489		
		·017615	1·05690
6	·105104		
		·017681	1·06086
7	·122785		
		·017756	1·06536
8	·140541		
		·017843	1·07058
9	·158384		
		·017943	1·07658
10	·176327		

In the last column the gun is supposed to be 60 inches in length, which being the radius, each of the differences in the preceding column is multiplied by 60: the difference between the tangents of the 9th and 10th degrees is then found to be $\frac{3}{100}$ of an inch longer than the difference between the tangents of the 1st and 2d degrees; as the slightest difference in the length of the tangent scale affects the range of the projectile, the tangent scale cannot be too exact.

It has been supposed that the tangent scale bears some relation to the distance from the base ring to the centre of the trunnion, but this is a mistake; the trunnion may be placed in any part of the bore, even at the extreme end of it, as with mortars. Trunnions are useful for elevating and depressing the piece, but the tangent scale, by which the elevation is regulated, depends on the length of the piece, or more correctly speaking, on the distance from the base ring to the

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top of the swell of the muzzle, taken in a direction parallel to the axis of the piece; this distance being the radius of the circle on the curve of which the tangent is to be constructed.

To construct a tangent scale for a gun without a patch of metal on the muzzle to mark the dispart, the following method is suggested. Take the diameters of the gun at the base ring, and at the swell of the muzzle, subtract the one from the other, and divide the difference by 2 for the height of the dispart; measure the distance from the rear part of the base ring C, to the top of the dispart D, (fig. 2 Plate 22) which will be the radius of the circle on the curve of which the tangent scale required is to be constructed. Suppose the distance CD to be equal to 8·8 feet or 105·6 inches corresponding nearly to a 12 pounder iron gun, then each of the natural tangents in the foregoing table multiplied by 105·6 inches will give the length of the tangent scale from 1 to 10 degrees.

Degrees.	The natural tangent multiplied by 105·6 inches.	Remarks.
1	1·843248	
2	3·6876576	
3	5·5342848	The whole number and
4	7·3842912	first two decimals would
5	9·2388384	be found sufficiently
6	11·0989824	near for practical pur-
7	12·9660960	poses.
8	14·8411260	
9	16·7253504	
10	18·6201312	

The dispart at D is about 1·95 inch, so that by looking over the base ring and muzzle, and laying the gun to an object, an elevation of little more than one degree is at once given to the bore of the gun, and consequently to the projectile above the plane of the object; the first line to be marked on the tangent scale will then be for 2 degrees, at 1·73 inch from the top (viz. 3·68—1·95)—the same deduction

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must be made in like manner from the tangents of the other degrees in succession; but should the dispart be fixed to the top of the muzzle, as is the case with some ordnance of modern construction, the tangent scale would then be of the full length corresponding to the length of the gun as shewn in the second column.

The following practical method of constructing a tangent scale, will perhaps be found useful, by the Artificer.

Draw the line CD (fig. 2 Plate 22) equal to the distance from the base ring to the sight on the muzzle, or to 8·8 feet as before supposed, and from D as a centre draw the curve CE, being the quarter of a circle, or 90 degrees, divide this curve into nine parts of 10 degrees each, and the lower part CF into ten equal parts of one degree each; draw the tangent or perpendicular line CG, and from D as a centre draw lines passing through the divisions of the curve until they meet the tangent, the points of contact on the line CG, will then denote the divisions of the tangent scale.

As it would perhaps be difficult to find a smooth surface on which to describe so large a figure as DCE, the length of the curve CF may be calculated in the following manner,

As the diameter.		The circumference.		The radius.		The semicircle.
1	:	3·1416	::	8·8	:	27·64608

27·64608 ÷ 18 = 1·53589 = curve CF or 10° or 18·43 inches, which divided by 10 gives 1·843 inch, the length of curve for each degree.

It is evident from the foregoing figure that the actual length of the curve CF representing 10 degrees, and the corresponding length of the tangent CG must depend on the length of the radius CD, or on the distance from the base ring to the sight on the muzzle, every gun should therefore be provided with a tangent scale so constructed.

An Artillery man practising with a piece of ordnance requires to know the exact distance of the object, this may be

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ascertained in the course of a few minutes by means of a base and the two subtended angles; he next determines the elevation and length of fuze, either by reference to a table or by simple rules which he may have committed to memory, the elevation is given by the tangent scale which must therefore be correct to ensure good practice.

The correctness of a tangent scale may be tested in the following manner.—Place the gun on a perfectly level piece of ground at about 20 yards from a perpendicular wall, lay the gun horizontally by means of a quadrant, then make a conspicuous mark on the wall at the same height as the sight on the muzzle is above the ground, should the gun have a patch of metal on the muzzle to mark the dispart, the notch on the base ring, the sight on the muzzle and the mark on the wall will be exactly in a line, next raise the tangent scale to the first division on it and lay the gun to the same mark on the wall, and ascertain the elevation of the bore of the gun by the quadrant, which should be the same as that denoted by the tangent scale, if not it may be presumed that the tangent scale is not correct. Next raise the tangent scale to the second division marked on it, lay the gun in the same manner to the mark on the wall, and take the elevation by the quadrant; repeat the same operation for each division on the tangent scale, write down the results, it will be seen at last to what extent the tangent scale coincides with the quadrant, and whether it should be considered as serviceable, or condemned.

To shew the practical use of the tangent scale let BC (fig. 3 Plate 22) represent the gun laid for the object, BA the tangent scale raised to give the elevation required for the distance AE and AC in line with the object E, then AB is the tangent of the angle ACB or its equivalent DCE which is the elevation given to the bore of the gun above the object E.

It is evident that the elevation by tangent scale can only correspond with the elevation by quadrant on perfectly hori-

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zontal ground, for by the tangent scale the elevation of the gun is the elevation above the object B and is said to be the number of degrees contained in an angle CAB (fig. 4 Plate 22) subtended between the direction of the bore AC and a direct line from the gun to the object AB whether above or below the horizontal line AD ; whereas the elevation by quadrant, is the elevation above the horizontal line EF (fig. 5 Plate 22) and is said to be the number of degrees contained in an angle GEF subtended between the direction of the bore of the gun EG and the horizon EF.

(Signed) J. W. CROGGAN, Lieut. Col.

KAMPTEE,
28th April 1856.

The monster Gun at the Mersey Steel and Iron Company's Works.

This marvellous piece of Ordnance, the greatest wonder in weapons of modern warfare, is progressing rapidly to completion. The barrel will be 15 feet long, it will be 27 inches in diameter at the muzzle, or $84\frac{3}{4}$ inches in circumference; and 44 inches in diameter at the breech, or $138\frac{1}{4}$ inches in circumference. The bore will be 13 feet 6 inches long, and 13 inches in diameter. When completed, it is estimated it will have cost the Company £3,000 in material and labour alone. The gun is expected to be ready in about six weeks, and, with the trunnions complete, will weigh something over 24 ton. The charge will be about 100 lb. of gunpowder, with one of the shot of 302 lb., and the trial will take place at Waterloo, near Liverpool.*

Note.—The true principle for securing great momentum, or heavy shot into high velocity, seems comprehended in the system of rifling guns of large calibre for Conoidal shot. The 68 pdr. rifled would throw a Conoidal shot of 130 lbs. Long and accurate range being due to the form of the shot, the former resulting from the Conoidal projectile presenting curves of least resistance to the atmosphere, and greater accuracy resulting from the rifled rotation, which neutralises the variations consequent on the centre of gravity not being identical with the centre of figure, exhibiting greater weight with the same diameter as spherical shot (atmospheric resistance is as the squares of diameters, the power to overcome resistance is as the cubes of the weights) and keeps the shot on the true line of projection.—G. W. Y. S.

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* United Service Gazette, 1st March 1856.

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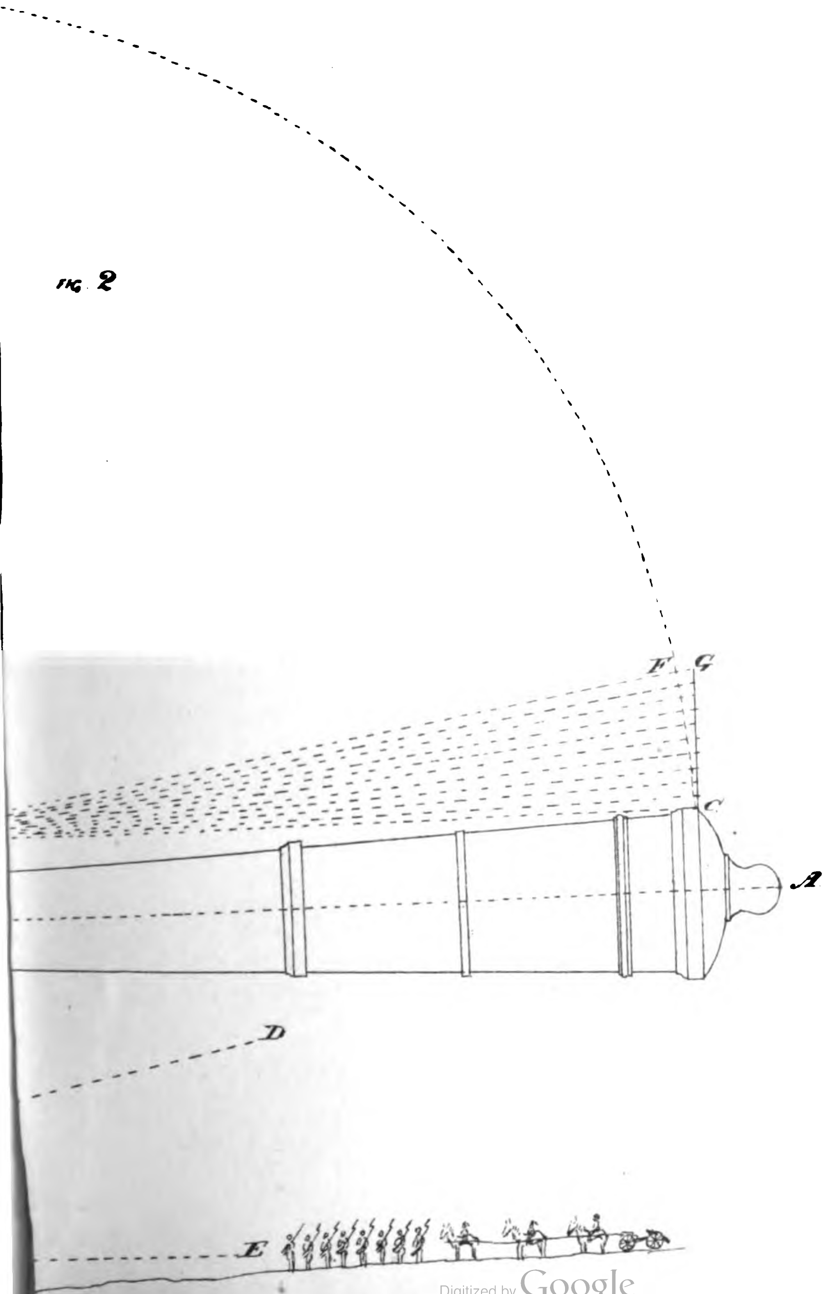
Plate 22.

FIG. 2



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Iron Charcoal Smelted.

BERLIN, *Oct.* 29.

As regards gun metal and iron guns, which form the main subject of inquiry for the commission that has been sent here by our Government, I have ascertained that the Prussians obtain by far the greater part, if not all, of their iron guns from Sweden. Further, I have been informed, as a matter beyond doubt, that the iron requisite for the purposes of ordnance is certainly charcoal iron. This comes to me from one of the highest authorities in physical science, and also from a man of considerable practical experience. The production of this species of iron in Sweden is, however, so far below the demand that the Swedish Government has for many years past forbidden its exportation as raw material. This prohibition, which formerly was only laxly observed, has been somewhat more strictly enforced during the last year or two. From Sweden, therefore, we cannot reckon on any supply of the requisite raw material.

The Silesian iron, which is also a charcoal iron, possesses most of the qualities inherent in the Swedish, being close and hard, with a tendency to brittleness, while the iron that is raised on the banks of the Rhine is for the most part smelted with coal. Of the latter there were till lately no large quantities raised, while of the Silesian the quantities brought to market seem now to have reached that point at which its produce must remain stationary. It has only been the high prices obtainable under the protective duty of the Zollverein that has enabled these charcoal smelting works to pay; and, now that the supply of wood within an available distance is consumed, higher prices will be required on account of the increased expense of fetching it from a greater distance; and, even with an advance of price, it is not impossible that the manufacture will experience a check until the necessary means of road or water communication are made, by which

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the wood can be brought to the ore, or the ore be taken to the wood. In last year the produce of the Rhenish mines rose from 719,684 tons to 1,068,656; the Westphalian from 146,320 to 330,014 tons; while in the Silesian district the increase was only from 563,739 to 650,369 tons. The amount of iron raised altogether in Prussia was previously to last year inconsiderable, and of no rapid increase; in 1848 it was 1,141,779 tons; and in 1853 it was still only 1,496,515 tons; at the end of 1854, however, it had become 2,144,509 tons. In spite of this rapid increase in the production of native iron the amount of English iron imported was never so great as of late, the northern provinces of Prussia being almost exclusively supplied from our mines, the difference between sea freight and canal carriage, between our prices and those inland, being greater than the amount of duty paid, setting aside the difficulty of getting any supply at all from the south and west of the kingdom.' The idea of deriving any amount of charcoal iron from Prussia must therefore not be entertained, and any information based upon the use of this quality of material will necessarily be of inferior moment.

In consequence of the heavy duty (4*l.* 12*s.* 6*d.* per ton) levied by the Zollverein on our bar iron, a large quantity of Silesian charcoal iron is used, particularly in the south of Prussia, for a number of common purposes, when an inferior iron, such as we could supply them with at infinitely lower prices, would suit them much better. But our low price, when it has been increased by duty, sea freight to Hamburg, Stade and Elbe duties, and freight-agents' commission, &c. (or, in the case of Stettin, increased sea freight, Sound dues, though with diminished duties and freight on the Oder), mounts up to more than the superior charcoal iron of Silesia does, and thus both we and the Prussians are deprived of the quality each wants.

The late prohibition of the export of bar iron to Prussia by our Government was a thorough blunder; it only put a

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premium on the flatting and rolling works here, and hastened towards its extinction a branch of trade that will of itself expire in a year or so. As regards bar iron, the extensive works which are already in existence here, and which are receiving constant increase, will soon put Prussia in a position to be independent of us for this *quasi* manufactured article as long as we supply them with the raw material—the pig iron. As the duty on this latter is only 1*l.* per ton, the difference between the two duties (1*l.* for pig and 4*l.* 12*s.* 6*d.* for bar) gives the Prussian iron works a profit of 3*l.* 12*s.* 6*d.*, in addition to the ordinary profit on the labour of rolling and hammering. Whenever our Government is disposed to blockade the ports of Northern Prussia, so as to prevent our manufacturers from obtaining Russian raw material, it can go a step further and prohibit the export of pig iron to Prussia. This measure would bring all the foundries and ironworks in Prussia north of Berlin to a standstill, and do ourselves an equal, though not a proportionately equal, amount of damage.

As regards the best qualities of iron for the purpose of casting ordnance, England need not look either to Sweden or to Prussia for a supply; she has it at her command in her own dominions, and the Government has already several parcels under trial that will relieve all anxiety on this point.

Iron and Brass Ordnance.

We have just received the report of the Commission some few months since appointed by Lord Panmure, Secretary of State for War, to make enquiries into the state of the manufacture of iron and brass ordnance in various continental states, on which some remarks will be found in the *Mining Journal* of Nov. 24 last. It appears the Commission visited the royal foundries at Liege, the charcoal smelting works at Charleroi, the various manufactories at Berlin, the bronze foundry at Munich, and then proceeded to Paris, stopping

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at Strasburg to visit the Government foundry for brass guns; here they inspected the saltpetre refinery, the percussion cap manufactory, and the large smelting works. They afterwards visited the cannon foundry at Ruelle, and the gunpowder works of Angoulême. In their report, the commissioners state that the methods adopted in manufacturing and testing the iron guns at Liege fully merit the high celebrity which has been obtained, and has induced other Governments to have recourse to it for the supply of their artillery services. The iron employed was of excellent quality, but charcoal iron was not considered exclusively important, as that principally employed was a grey charcoal iron, mixed with old cast-ircn, and dead heads. The patterns and models used were of metal, very carefully finished and polished, and, unless otherwise injured, would last a century. The principal brass gun foundries are situate in Berlin, and when completed the Spandau Cannon Foundry will be the most complete on the Continent; but in none of them is there much advance, as compared with the systems pursued in England. They then describe the saltpetre works, the gunpowder manufactories, and those for fulminate of mercury, and percussion caps. The report concludes by expressing the opinion that a careful examination into the general organisation of continental manufactories would result in many positive improvements here, as well as in the removal of many obstacles in the path of our national progress.

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Russian Gun Carriages.

To the Editor of the United Service Magazine.

Sir,—The description of a Russian gun-carriage in the number for November* has induced me to trouble you with these remarks on what appears to me to be the use of the holes in the tire of the wheel.

It is very certain that the Russians have in the present war employed metal of a much heavier kind than we are in the habit of using; the carriage alluded to is capable of being adapted for service in the field with heavy guns as well as in a battery. The projecting axle is clearly intended for a larger wheel than that shewn in the sketch: the diameter of field gun wheels is five feet, or double that therein described. The difficulty will be to ship the larger wheel with celerity. To render this operation easy seems to me to be the object of the tire holes. I send a sketch to make my idea understood—(Plate 23.)

Let A, B, C, be an inclined plane; *a*, *a*, *a*, cogs fixed at its outside edge; the holes on the tire are, I think, as *b*, *b*, *b* intended to be worked by the levers *c*, *c*, and to catch on the cogs *a*, *a*, *a*. No other raising power easily transported from place to place would suffice even for an 18 pounder, the weight of the gun being 42 cwt., and the weight of the carriage, nearly the whole of which would be dead weight to be raised 18 cwt., or a total of three tons.

The trail roller seems intended to diminish the friction of the trail on the ground during the operation.

Your obedient Servant,

C.

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* Artillery Records "Miscellaneous" page 339.

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Instructions for making the best Antifriction Grease.

The following Receipts for making the Grease used for Railway axles in England were obtained (1856) from an Engineer Officer, and Government Inspector of Railways, but great difference of opinion exists as to the best mixture.

No. 1.

Put in the copper,			After gently boiling put them in tubs to cool.
70	lbs.	tallow.	
35	,,	palm oil.	
128	,,	water.	
4	,,	soda.	

Sometimes sulphur of brimstone and occasionally black-lead is added to the grease.

No. 2.

Water................	1	gallon.
Palm oil.............	3	lbs.
Tallow................	6	,,
Common soda.......	½	,,

Receipts for making the material (Dextrine) used for Postage Stamps in England.

Starch converted by the action of acids, diastase, or heat, into a soluble substance resembling gum, and frequently substituted for gum arabic and much used in France by Confectioners and Doctors, and used in London for putting on the back of Postage Stamps.

The best mode of preparing it is that of Mr. Payen, viz. Dry starch 1 ton, moistened with 4½ lbs. of strong nitric acid, it is then made into bricks or loaves and dried in a stove, it is then reduced to powder and exposed to a temperature of 160° to 165° Fahrenheit, it is then ground, sifted, and exposed to a temperature of 220° Fahrenheit.

Another method is to expose dry potato starch to a temperature of about 400° Fahrenheit, but this is inferior.

Whenever starch is heated with an acid it is converted first into Dextrine and then into Grape Sugar.

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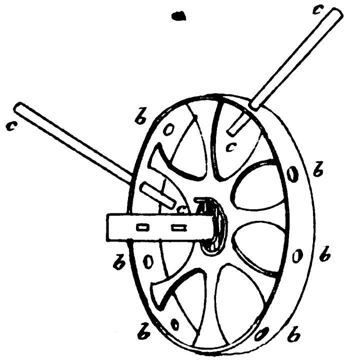
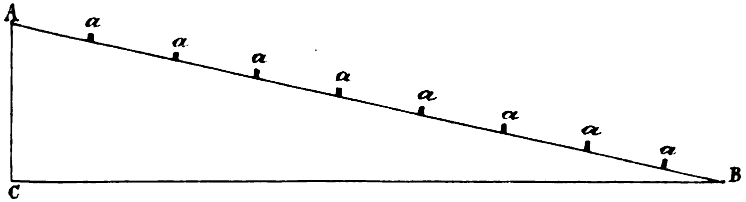
Miscellaneous.

Russian Gun Carriages.





Madras Artʸ Depot H.J.K.

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RIFLED ORDNANCE.

Mr. Bashley Britten's Invention.

Communicated by Major G. W. Y. Simpson, Superintendent Gun Powder Manufactory, Madras.

"Next, there is the demand for a good rifled Cannon, or, if not rifled, one that by the character of its bore shall make projectiles rotate properly upon their axis. This is a result which it is of the utmost consequence to attain.

"The Lancaster gun bursts so frequently in service, and is so uncertain in the flight of its projectile, that the authorities look back with feelings of discouragement, almost amounting to disgust, at the enormous sums expended in the vain endeavour to control its caprices," "First, the gun is made too strong for the shell, and then the latter is strengthened, but the gun gives way, *the real truth being that an iron missile will not adapt itself to the increasing pitch of the oval bore. It gets jammed in rushing out, and in the struggle which ensues, one or other must give way.*"—Vide the *Times*' Report of Her Majesty's visit to Woolwich Arsenal, December 3d, 1855.

The above stated obstacle to the success of the Lancaster principle of rifling ordnance has been from the first perceived and pointed out by most men possessing any practical knowledge of mechanics; and it is much to be regretted that the fact should not have been earlier recognised by the authorities themselves, before the enormous sums of public money which have been lavished on this invention had been permitted to be thrown away.

The nature of the invention, which is referred to in the following pages, can be at once understood by examining the accompanying sketch (Plate 24) of the section of one of the compound projectiles. The principal advantages of Mr. Britten's invention over that of Mr. Lancaster's are as follows:—

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1. Mr. Britten's shells, being principally of *cast iron*, can be made for only a trifle beyond the cost of the common shot and shell of the service; and this additional cost would be more than compensated for by a great saving effected in the charge of powder.	Mr. Lancaster's shells require to be made of the *best wrought iron plates*, welded and shaped by machinery of the most costly and complicated character, and afterwards turned all over in an eccentric lathe, so that the total cost of each shell amounts to several pounds sterling.
2. The rifling of the gun acts only on the soft metal upon Mr. Britten's shell in the same way as in the Enfield rifle bullet.	The bursting of the Lancaster guns is owing to the rigid nature of the material of the shells.
3. For employing Mr. Britten's shells *the present guns can be used*; all that is required is to have a few shallow spiral grooves cut down the bore—an operation very simple and inexpensive, and which would not weaken the gun.	The Lancaster shells require guns to be cast and bored expressly for their use.
4. The lead on Mr. Britten's shells expands with the action of the powder, and entirely fills up the bore, causing much less wear to the gun, and ensuring a perfect direction of flight.	The Lancaster shells must necessarily be made somewhat smaller than the bore, so that there is a great loss of effect from windage, and no accuracy can be obtained with any certainty.
5. The round service shot, when necessary, can be fired, with hardly any disadvantage, from the guns suitably rifled for Mr. Britten's shells.	The oval bore of the Lancaster guns entirely prevents the use of the round shot, except at an enormous sacrifice of power.

Mr. Britten's invention has now been tested at Shoeburyness four times successfully.

It has been admitted by the Government to have realised *upwards of* 1000 *yards more effective range than the service ammunition from a* 9 *pounder field-piece, and with little more than half the service charge of powder.* It has been under

official consideration nearly fourteen months; and there is now every reason to fear that no further steps will be allowed to be taken to render it available, unless the matter is pressed upon the authorities by some PERSON OF INFLUENCE.

The inventor has therefore published these pages in the hope that their circulation may lead to the proper investigation of the subject; and, as he has in his possession official documents which fully substantiate all that is herein stated, he will be happy to exhibit them to any one who may desire to see them.

Anerley, Norwood, January 1856.

Improved Artillery.

(From the "Times" of August 2d, 1855.*)*

TO THE EDITOR.

Sir,—I beg to enclose you the particulars of some important experiments made at Shoeburyness on the 26th instant, under the superintendence of Colonel Mitchell, Commanding the Royal Artillery, for the purpose of further testing an invention which I brought before the Government in the month of November last, and which, from that time to the present, I have been incessantly urging on the authorities the importance of properly investigating without any loss of time.

It will be seen from the figures below, that without at all straining the gun used, my shells, with little more than half charges of powder, acquired an effective range of about 1000 yards more than the solid shot of the service with a full charge, while in point of accuracy my projectiles were far superior.

These shells will hold considerably more powder than the shells of the service, and can be made to explode on striking in precisely the same manner as the Lancaster shells.

It would take up too much of your space to state the

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wearying obstructions I have encountered in urging this matter to its present stage. The thing is extremely simple and obvious, and might have been tested, matured, and made useful long ago; but for some reason or other, the long period of nine months, during which any improvements in our means of attack would certainly have been of service to us, has been entirely sacrificed.

One of the most important features of the invention is the facility with which it may be adapted, and the economy of its employment. All that is required is a trifling alteration in our present guns, which need not cost more than a few shillings each, and which, with proper machinery, could be made on board ship just as readily as elsewhere, and which would not weaken the gun or interfere with the use of the service charge when preferred. The gun used in the experiments was a common gun with the alteration.

The new shells would cost but little more than the ordinary ones (not being required to be made of wrought iron and turned, like the Lancasters): and, taking into account the saving in some respects, the whole cost would not be greater than that of the ordinary charge of common guns.

I am induced, sir, to offer this explanation to the public through you, because I deem it a matter of no small interest, affecting every individual of the community. Up to this time I have fought my way single handed, unaided by any interest, and bearing all expenses. Four months ago my principle was tried and found successful, and I believe reported on favourably by the Select Committee, although I may observe, that when first I brought it forward it was reported by the "proper Officers" to be utterly impracticable.

Striking as the following figures undoubtedly are, I believe they show only an instalment of the success which may be looked for at the maturity of the invention. It is, however, not a matter which any person can possibly carry out by

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himself, whatever sacrifice of time or money he may be disposed to make.

The question therefore is—Will the Government now take the subject up properly and enable me to carry it on to completion?

The only thing I require is the authority to make a few more experiments; but, in order to be usefui, they must be on a very much larger scale than hitherto, and entered into in a more free and liberal spirit, with perhaps a little more assistance from Military experience, savouring less of criticism on my efforts as a civilian.

If such a course were authorized, I feel certain that in a short period results might be worked out that would eventually lead to as complete a revolution in our system of Artillery as that which is now in course of progress in small arms.

I have the honor to be, &c.

(Signed) Bashley Britten.

Experiments made at Shoe-buryness on the 26th July, under Lieutenant Colonel Mitchell, R. A., with 9 pounder guns and some shells, on a new principle, invented by Bashley Britten. These shells can be made to explode with perfect certainty at the moment of striking, or the time fuse may be used with them.

Weight of Shot.	Charge of Powder.	Elevation of Gun.	Recoil.		Direction from line of Aim.	First graze	Extreme range.	
lbs.	lbs.	deg.	ft.	in.	yards.	yds.	yds.	
9	3	5	4	0	36	1700	2400	Service solid shot with service charge.
9	3	5	....		39	1675	2000	
14¼	1¾	5	4	4	3	1920	3200	Mr. Britten's shells.
14¼	2	5	5	10	8	2075	3800	
9	3	10	6	0	40	2240	2600	Service solid shot, usual charge.
14¼	1¾	10	4	10	10	3225	3700	Mr. Britten's shells.
14¼	2	10	5	10	13	3275	3800	
14¼	2¼	10	6	3	42	3065	3400	
9	3	11 6	6	3	74	2850	2850	Service solid shell.
14¼	1¾	12	4	10	12	3620	3800	Mr. Britten's shell.

The above figures are from the official account.

House of Commons.

(From the "Times" August 3, 1855.)

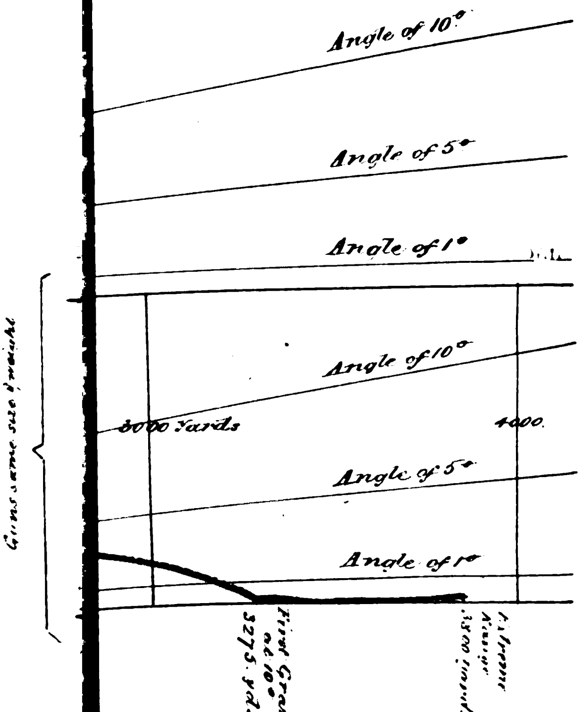
Improvement in Projectiles.

On the motion for going into Committee of Supply,

Mr. Roebuck inquired of the clerk of the Ordnance whether it was true that some experiments were tried at Shoeburyness last week, under the superintendence of the Colone of the Royal Artillery, with the following important results;—That with only about half charges of the powder, and from a gun with a trifling alteration, the experimental shells acquired, at similar elevations, upwards of 1000 yards more effective range than the solid shot of the service with a full charge, and that the average deflection of the experimental shells fired was only fourteen yards, in this increased distance, while that of the service shot, at the smaller range, was forty-seven yards? Further, was it true that this invention had been nine months before the Government that at first it was reported to be of no importance, that, on it being pressed on the notice of the Duke of Newcastle, it was referred to the Select Committee at Woolwich in January last, and it was experimentally proved successful in March; and that no assistance had been afforded to the Inventor for maturing his invention, beyond merely authorizing a few experiments to be made at his expense? Further, was there any obstacle to the adoption and use of this great improvement in the effectiveness of our Artillery?

Mr. Monsell believed that the result of the experiments made last week at Shoeburyness had been as stated by the hon. member for Sheffield, with one exception, which was that the experimental shells had been fired from a rifled gun, and the service ammunition from a gun with a smooth bore. It was true that this invention had been nine months before the Government. In the first instance, it had been submitted to the Director General of Artillery, General Cator, who, from the constant failure of experimental shells, had

Plate 24.



powder is 3000 yds at 11° elevation

H J ROCKEN . LITHOG.

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not deemed it one of great utility. It was subsequently brought before the Select Committee by order of the Duke of Newcastle, and an experiment was made in March last at Shoeburyness, but upon that occasion Mr. Britten's projectile manifested an inferiority to the service shot.* Another experiment was made in May with a similar result; and he believed that the experimental shells tried the other day by Mr. Britten was different in some respects from those tried upon the two former occasions, improvements having been, recently made which *had resulted in the success of the experiment.* In answer to the last question of the hon. gentleman, he could assure him, that the attention of the Committee was now turned to the invention, and if upon further consideration it was worthy of adoption, means would be taken to render it available. Mr. ROEBUCK said that the hon. gentleman had not answered that part of his question as to the results of the experiments.

Mr. MONSELL; *I said that the results of the experiment had been such as was stated by the hon. member in his question.* (Hear, hear.)

(*From Major* YOUNG SIMPSON, *Madras Artillery, Director of the Depot of Military Instruction, Madras.*)

9, *Eastbourne Terrace, August* 15*th*, 1855.

Dear Sir,—I had the pleasure of receiving your very interesting letter, with the sketch (Plate 24) of the shell, last

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* It is clear from the above that Mr. Monsell had been quite misinformed respecting the results of the experiments in March.

On that occasion, two of the compound projectiles, being fired with too much powder, which interferred with the action of the rifling of the gun, failed in point of range.

A third shot, with 2 lb. of powder fired from the rifled gun at one degree of elevation, first grazed at 1114 yards, with only two yards deflection. The range of the service ball from the common gun, at the same elevation and with 3 lb. of powder, was no more than 7[illegible]4 yards, or *only two-thirds of the range of the rifle shot.*

Two of the same compound projectiles were fired from the smooth bore, but they did not succeed, thereby clearly proving that the rifling of the gun was essential.

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evening; and as I have an engagement in the City this afternoon, to conclude the arrangements for my passage to India, my reply must be more hurried than I could desire. Your shell does, as you justly observe, meet all those conditions which in my last I specified as essential to long range and accuracy of fire, and which I may repeat:—1. Windage reduced. 2. Form of shell offering curves of least resistance to the atmosphere. 3. Greater weight than the service shells, with no increase of surface to encounter atmospheric resistance. 4. The centre of gravity anterior to the centre of figure of projectile. 5. The rifled cylinder causing rotatory motion.

I should estimate the windage of your shell to be the lowest possible amount which a shot can have, and this without entailing one single difficulty in the loading, or any other disadvantage; for looking at the figure and position of the lead on your shell there can be no doubt that the first action of the inflamed powder is to bulge out the lead in the direction of the lines of the least resistance, thus filling up both the rifled grooves and the cylinder of the bore, so that the escape of the gas over the shell is minimised, and the fullest impulse that the charge is capable of imparting communicated to the shell, *now, when the great loss of propellant force through the windage ring with service shot is considered, it is not possible, I think, to over appreciate, combined with the other equally great advantages exhibited in your shell, the extreme value of the step in advance you have established in practical gunnery. The great range (and accuracy) of your shell is due to the combination of conditions above referred to, and is therefore explained and accounted for on sound admitted axioms of gunnery.* Congratulating you very heartily on the great success you have achieved, and wishing you all the advantage due to that success.

I remain, dear Sir, yours truly,

(Signed) George Y. Simpson.

B. Britten, Esq.

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N. B.—Mr. Britten has no other acquaintance with Major Simpson but what arose from the publication of the results of the foregoing experiments, and it has been confined to a single interview, and the interchange of a brief correspondence on the subject of this invention.

Britten's Improved Shells.

(From the "Times" of August 23d, 1855.—By the "Times'" own Reporter.)

Further experiments were made yesterday at Shoebury-ness, under the direction of Lieutenant Colonel Mitchell, Royal Artillery, with the new shells invented by Mr. Bashley Britten. It will be remembered that, according to the official return published, these projectiles, when last tried, acquired an effective range of about 1000 yards more than the service solid shot, and this with little more than half the usual charge of powder. Since that period the inventor has slightly altered the form of the hinder part of his shells, conceiving that this would still further increase their range. His expectations, however, have not been fulfilled in that respect, and yesterday the new shells, though they maintained their superiority as regards the service shot, fell short of the range last obtained by about 300 or 400 yards. Of course the best possible form is not to be arrived at all at once, and in this instance experience seems to teach that the shape of the shell used on the 26th ultimo, is best adapted to ensure both extent of range and accuracy of aim. *In any case there now appears no reason to doubt the soundness of the principle.* Mr. Britten claims for his projectiles the power of the Lancaster shells, with far greater accuracy of flight, and with a very trifling increase of cost, if any, *over the ordinary service shot.* Of seven experimental shells fired yesterday, six were projected from a rifled 9 pounder, the object being to carry out the principle of the Minié rifle, and to procure for the shot the rotatory motion. Whether this motion is or is not secured seems to be a moot point, but that the grooves exert

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some influence would certainly appear to be shown by the fact that the only experimental shell fired from a smooth bore was a failure. The longest flight taken by the new shell yesterday was 3150 yards, which represents the first graze, not the extreme range; this was at an elevation of $11\frac{1}{2}$ degrees, with a powder charge of $1\frac{3}{4}$ lb. *At the same elevation, and with a 3 lb. charge of powder, the service shot fell short of this range by some 600 yards.*

One noticeable feature with regard to the experimental shot was, that the increase of the charge from $1\frac{3}{4}$ lb. to 2 lb., instead of adding to the range, diminished it. Their conical shape allows of a greater weight in the Britten shells as compared with the service shot of the same calibre. The weight of the experimental shot fired from the 9 pounder gun was 14 lb., yet the charge of powder used was $1\frac{3}{4}$ lb. as against 3 lb. for the service ball of less weight. The advantages thus gained are apparent. *By adopting these projectiles a 9 pounder gun is virtually converted into a 14 pounder, and so with cannon of greater calibre.* The strain upon the gun also is of course considerably less, owing to the diminished charges required. An insuperable difficulty has hitherto been experienced in so coating the body of an iron projectile with soft metal at its hinder part that it shall expand and fill the bore of the gun when fired, in order to prevent what is technically known as "windage," and, by adapting itself to the grooves in its passage, to give the ball a rotatory motion. Previously to this invention, it had not been found possible to render the union of the iron and the lead, or softer metal, so complete that the latter would stand the explosive force of the powder. Mr. Britten, however, has overcome this difficulty, and has thus reduced the "windage," or waste of projecting power, to perhaps the lowest possible amount. Independently of the rotatory motion, if that be gained, the filling up of the bore in this way so steadies the ball that it is not forced violently at any one point against the sides of the gun, and, the pressure being equal throughout, this constant cause of

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wear and tear in our present Artillery is avoided. By the conical form of the new shell the amount of atmospheric resistance is, of course, considerably reduced as compared with spherical shot, and the centre of gravity is so placed that the missile flies with its point always in advance. It may thus be made to explode on striking in the same manner as the Lancaster shells, or it may be used, as was the case yesterday, without being charged with powder at all.

The experiments were made at different degrees of elevation, but with only one description of shell—the 9 pounder being the only rifled gun yet adapted for practice with these projectiles. It seems very desirable that they should be tested as soon as possible with guns of a larger calibre. If the principle is good for anything, no time should be lost in applying it—at least this is the conclusion which presents itself to unofficial minds; and an invention which promises to add half a mile more to the range of our Artillery may be thought worth trying on a large scale. The inventor has not much to cheer him in his past attempts to improve the science of gunnery. He has already stated in his published letters that "the proper Officers," to whom his plan was first referred, looked upon it as not appearing of sufficient advantage to the service to call for further consideration; and to this may be added Mr. Monsell's admission that the invention has already been nine months before the Government. There is not much in these facts to encourage inventors.

Improved Artillery.

(From the "Times" of October 31, 1855.*)*

To the Editor.

Sir,—As you have more than once done me the honor to insert a notice of my invention relating to the above subject, I take the liberty of sending you a few particulars respecting some further experiments which were made at Shoeburyness, under Lieutenant Colonel Mitchell, R. A. on Wednesday and Thursday last.

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It will be recollected that it was admitted by Mr. Monsell in the House of Commons, that in July last my shells acquired an effective range of more than 1000 yards beyond the service solid shot from the same sized gun, and at the same degree of elevation, with little more than half the usual quantity of powder. The reason that so little has been done in the matter since then is very curious. On recovery of the shells then fired it was found that they had not received the impression of the rifled grooves. The authorities therefore reported that the principle of my invention had not been proved, and that the long range was attributable to the increased weight and diminished windage of the shells, and *not to the action of the rifle.*

I protested strongly against the unsoundness of this conclusion—first, on the ground that the shells could not have been thrown so far unless the rifling had operated; secondly, that it was obviously a secondary point what had caused the advantage, provided the result was obtained. To settle this question, I obtained permission to have some of the same shells fired from a smooth bored gun, and the result proved just as I anticipated. The latter projected the shells to an extreme distance of 1800 yards, with 2 lb. of powder, while the rifled gun threw them 3800 yards with $1\frac{3}{4}$ lb. This point is confirmed by two shots fired on the 13th March from a smooth bored gun. I have all along complained that the gun I have been allowed to use was not rifled in the way it should be, and to this I attributed the fact of the shells not being marked. I have all through been told by the Select Committee, that other more properly rifled guns were about to be prepared; but for some unexplained reasons this has not yet been done.

For the last experiments I constructed the shells in such a manner as to ensure their expanding into, and filling up, the grooves; and this time it has been found that they have taken the impression of the grooves most distinctly, proving hereby incontestably that the desired rotatory motion was

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in this instance communicated to them ; but, strange to say, this very thing, for which the matter has been ostensibly so long kept in abeyance, did not in any important degree add to the range acquired in my first experiments.

The regulations of the Ordnance Committee do not permit me to publish the details of the experiments ; I can therefore simply furnish you with the general results.

The gun used was an ordinary 9 pounder iron field piece of 17 cwt, with four grooves cut down the bore. Twenty-two rounds were fired from this gun, the shells weighing about 15¼ lbs. each, and the charge of powder being 1¾ lbs. The usual charge for the same sized gun is 3 lb. of powder, and a ball of 9 lb. When fired at 10° elevation, the shells first grazed at upwards of 3000 yards, and after that they ricochetted for 700 to 800 yards more, showing the great momentum they had acquired. At 12° this distance was increased by several hundred yards. With a view to show the accuracy of flight which may be depended upon, in the last few rounds I had the gun pointed so as to allow for the constant deflection on one side caused by the rifling, in which manner I propose that the guns should be sighted.

The weather was extremely boisterous, but, notwithstanding this, in three or four shots the projectiles grazed at only a few feet from the line aimed at, at a distance of nearly two miles from the gun.

In judging of the effectiveness of these missiles, it must be remembered that it is a body just two-thirds heavier than the solid ball which is thus thrown this greatly increased distance from the same sized gun ; besides this, they carry with them a heavy bursting charge, which will explode the moment the shells strike—with what effect it would be an interesting point to ascertain in the harbour of Cronstadt, or among the shipping about Cherson.

I may further state, that they may be employed by Government at no additional expense beyond that of the common ammunition, because, although the shells themselves

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might cost about 15 per cent. per ton more than the ordinary shells, this would be compensated for by the saving of nearly 50 per cent. of the powder; while the few shillings each it would cost to alter the present guns into rifles would, I believe, be much more than made up for by the diminished wear consequent on so little powder being used. Such is a brief but true description of what has been and may be done with this extremely simple invention, which will within a few weeks have been twelve months under official consideration!

I am, Sir,
Your very obedient Servant,
(Signed) BASHLEY BRITTEN.

Ignition of Sulphur at the Gunpowder Manufactory Madras, on the 12th July 1856.

Letter No. 113, from Major G. W. Y. Simpson, Superintendent of the Gunpowder Manufactory to the Secretary to the Military Board, dated 15th July 1856.

Sir,—It seems advisable that I should bring to the knowledge of the Board an incident which occurred on Saturday morning last, in the Sulphur Store Room attached to the Mills, as a curious and interesting fact, entirely unconnected with any risk or danger to the stores in question.

The work people while removing an upper tier of Sulphur Barrels (preparatory to the weighing of the same by the Committee taking stock) found it necessary to roll them over the lower portion of the Sulphur, and after continuing this work for a short time, it was observed that the latter portion of the Sulphur heated by the friction of the rolling barrels, exhibited a surface of light lambent flame. This flame was of course immediately and easily extinguished, none of the Sulphur being lost or damaged.

The work of lowering the barrels, I may add, was subsequently carried on over planking forming an inclined plane passing clear of the lower tiers of Sulphur.

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On Congreve Rockets by Lieut. Col. P. Anstruther, C. B.

To

The Director of the Artillery Depôt of Instruction,
Saint Thomas' Mount.

Sir,—1. I beg to recommend that you should apply to the Home Government for a small supply of Congreve Rockets, and thus give our Officers the opportunity of learning how to use these projectiles.

2. Authorities differ widely as to the real value of this weapon, but the same variety of opinion is found to exist with regard to all other weapons; one Commander in Chief of the Bengal Army said he did not know what use Artillery would be in forcing a mountain pass; he found however that the Sipahis would not go in without Artillery; Major Seton and Major General Montgomerie declare shrapnells useless; but Major Moore at 650 yards preferred using shrapnell to round against a wall, and his first shell killed the Governor of the place; disliking shell, General Montgomerie directed the disuse of Howitzers (Mountain Train); immediately afterwards came the street fighting of Ningpo, 10th March, when the Howitzer was the most useful weapon ever known, for canister at pistol distance. Marshal Marmont has given it as his opinion that the Power which shall first introduce Congreve Rockets will have an enormous advantage for the first year of war over any opponent,—our Artillery authorities seem to despise the weapon. I will not give an opinion: but we found Rockets very useful at Canton Heights, at Chusan, and at Chinhae. I think they ought to have been largely used in the bush in South Africa, and at all events I think we ought to have some practice with them. We used them in the last Burmese war very successfully; they are so much more easily carried with the advance of a column than Field Pieces, that I think no force should ever march without them

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and therefore Artillery Officers should be taught, in time of peace how to use them in war.

But, only fresh, new, Rockets are to be depended upon. We ought to have a yearly supply, and expend it; the best plan would be to ask for a half yearly supply, and on receipt of a new shipment have 3 or 4 days practice with Rockets and expend all in store, ordering all Officers and all Non-Commissioned Officers at the Station to attend, so as to risk as few men as possible. At Canton the Madras Rockets were utterly useless, and dangerous to their owner; we did not dare to continue. using them, but we took those brought by the Royal Artillery serving with us, and one of the earliest fired, hit a round tower, very well built of stone, hit it full and dashed two embrasures into one, throwing a storm of granite into the confined space of the battery and clearing it completely.

No old Rocket should be kept.—If for economy's sake you object to destroying them, send them home to be refilled, as there is no hope that they will let us know the secret of their composition. But let us have, every 6 months, a new supply and let us learn how to use them; as yet we have always had to learn in presence of the enemy, what ought to have been made familiar to us in time of peace.

Many of our Officers are practised Rocket-men—Lieut. Colonel Moore, C. B., Lieut. Colonel Balfour, C. B., Major Gabbett, Captain Barrow, Captain Little, Captains Cadell, Macpherson, Baker, Purvis, Molesworth, Collingwood, Waddell, Stuart, Hicks, Harrison, Laurie, all have seen Rockets used, but we have now no means of keeping up the knowledge gained—we shall utterly lose that acquired.

We read that the Maha Bundoola was killed by a Rocket at Donabew in the first Burmese war; that shot was of more value than an attack by a thousand bayonets would have been.

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The Rocket is often the only Artillery that can accompany a Division, it is a pity to lose altogether the knowledge of the weapon.

I have the honor to be, &c.

(Signed) P. ANSTRUTHER, Major Lt. Col.,

Madras, 10th Nov. 1855. *5th Battalion.*

Burmese Black Varnish.

Letter from Lieutenant C. Raikes Madras Artillery, to the Director Artillery Depôt St. Thomas' Mount, dated, Shuay-Gkeen 8th December 1855.

Sir,—I beg leave to bring to your notice how admirably the Burmese Black Varnish (by them called "thit-tsee") is adapted for the preservation of wood or iron, and how excellent a composition it is for lacquering shot or shell, as well as for all iron guns &c. &c. I have lacquered all the shells in the Magazine at this Station under my charge with it, and have found it answer to perfection, and the cost is very trifling, as enough for 208 shells (5½ inch) cost only 3 annas. It is a species of gum which exudes from a tree, and imparts a most brilliant black gloss to whatever it is put on. It however makes cloth or leather quite rotten. I hear it has once before been tried in the Gun Carriage Manufactory and was condemned, but I consider that was in consequence of the article it was tried on being put in the *sun* to dry, whereas *damp* is required for that purpose. The proper method is to apply it smoothly with a common paint brush in the sun, and then to place the article to which it has been applied in as cool and damp a place as possible, and in about 4 or 5 days it will be thouroughly dry. If the article is surrounded with wet cloths or kuskus tatties so that they do not touch it, and thus exposed to the wind, it dries much more quickly. It completely preserves all iron from the effect of rust, and if applied to rattan or wicker work &c.—baskets, makes them waterproof.

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Iron Manufacture—Monster Wrought Iron Guns.

Sir,—In your Journal of March 8, I find a letter signed "Hammered Iron," containing several erroneous statements, which, unwilling as I am to be drawn into a public correspondence, I cannot allow to remain uncontradicted. Into matters of opinion or theory it is not my intention to enter on the present occasion, but I shall endeavour to confine myself to a few facts. I do not feel myself called upon to explain how the gun now making at the Mersey Iron-Works was put together, but simply state it was not built in the way implied by "Hammered Iron."

"Hammered Iron" is of opinion that the iron of the gun is so crystalised, that it has not *half the resisting power of cast-iron*. In answer to this, I can only refer him, or any other party interested in this question, to the samples of the borings from the heart of the gun which I sent to your office, and which you kindly allow to remain there for inspection.

These shavings, or borings, are some of them curled round seven times, like a watch-spring; and I must say, in my humble opinion, any person who sees them must at once admit that the theoretical fable of crystallisation does not hold good, at any rate, in this case. I am having the borings from the inside and the turnings from the outside worked up again separately into bar-iron; and they, in comparison with some pieces of the original iron of which the gun was made, are to be tested by a civil engineer, empowered by Government to enquire into this question.

"Hammered Iron" says, "I would advise the Mersey Company to prove their gun well before sending it off, for I remember the painful circumstances which attended the firing of the bow gun of the American frigate *Princeton*, and the deaths which took place when the gun on a gala day exploded. It was the largest gun of wrought-iron which had ever been made up to that time, and the Mersey Company made it and proved it." I beg to say this statement is entirely erro-

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neous. The gun that burst on board the *Princeton* was of American manufacture: that made by the Mersey Company, in 1845, for the American Government, I believe was never on board the *Princeton*—but, at any rate, I saw it at the chief navy yard of the United States six years after the gun made in America (of cast-iron, I was informed) burst, and it was in perfect order then, and will be found so, I have no doubt, when it is required. The American authorities, at the time I name, were taking excellent care of it.

In case further facts are desired in refutation of the most unjustifiable statements of "Hammered Iron," I refer any party interested to the fourth edition of the work of Sir Howard Douglas, on *Naval Gunnery*, pp. 109, 613: in both places he distinctly states that the gun made by the Mersey Company was to replace the monster gun which burst on board the *Princeton*.

The gun made by the Mersey Company was proved as follows, on the North Shore, Liverpool:—

1st. Charge of powder, 30 lbs., 1 shot and wad.

2d to 4th. Three charges of powder, each 44 lbs., 2 shots and wads.

3d to 30th. Twenty-six charges of powder, each 30 lbs., 1 shot and wad.

I was informed, at one of the American navy yards, that when the gun arrived in America, the authorities there still further proved it, and more especially with regard to its power. They made a target, composd of about twelve ½-inch thick boiler plates, which were placed against 3 feet thick of solid oak; and with that thickness of material the shot from this gun punched out the plates, passed through the wood, and was lost in the butt behind. The iron plates, punched as described, were shown me as one of the curiosities of the yard.

"Hammered Iron" is also wrong in supposing that the

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guns made for Alexandria, of cast-iron, were heavier than that now making at the Mersey forge. Again quoting Sir Howard Douglas, page 188, I find that one gun for Alexandria weighed 11 tons, another 18 tons, and the mortar 13 tons; whereas the Mersey gun will be about 22 tons when finished. I may perhaps also mention the reason why the Mersey Company gratuitously undertook this work: there would have been no use, after the several failures that took place, in asking for an order from Government; but the Government could not well refuse a gift; and believing, as the Mersey Company did, from their former successful manufacture of the American gun, that crystallisation was a myth, they resolved to manufacture a gun as large or larger than had ever been before attempted; and for this, I think, they deserve the thanks of all interested in forged iron, instead of (to say the least) the discouraging comments of one of the trade. I am willing to believe that the letter of "Hammered Iron" was written in ignorance of the facts, and not in malice. All I can say is, that I shall be happy to see him at any time at these works, and I trust to be able to make a convert of him (and he will not be the first) to the doctrine of the possibility of making large forgings without destroying the fibre of the iron. That there is great difficulty and risk of unsoundness in the manufacture of large masses of wrought-iron, unless the greatest care be used, I quite admit, but altogether deny the theory of crystallisation (as popularly understood), where proper attention is paid to the manufacture.

In conclusion, allow me to state that I am not aware of having expressed great confidence in the result. Our business was to make a large piece of iron good and sound, and free from crystallisation. The task is done; and whether it answers as a piece of ordnance or not is another question, to be decided elsewhere.

(Signed) Wm. Clay.

Mersey Iron-Works, Liverpool.—March 22, 1856.

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Ordnance Experiments on Metals in the United States.

A comprehensive work on this subject has been published in Philadelphia, by the authority of the Secretary of War. In order to ascertain the strength and properties of metals used for cannon, the Government of the United States ordered that an examination should be instituted by the officers of the Ordnance Department. They were empowered to study the several methods pursued at the best foundries in Europe, and a comparative trial of pattern guns turned out at several of them with the like cast in the States, confirmed their opinion as to the necessity of investigating the nature of iron ore, and its proper treatment before it could be used with safety for guns, and especially for those of weights suitable for field service. It was found that cast-iron was the best present resource for heavy sea coast, siege, and garrison cannon, but for the lighter field pieces it was resolved to adopt bronze, as a material not liable to burst into fragments. A test was devised, and all guns that were doubtful or bad were reserved from issue, and at the foundries the superintending officer was directed to ascertain the qualities of cast-iron and bronze, to test the ores and guns in every stage to completion, to provide proper tests and processes for general use, and means and machines for applying them. The experiments extended over the years 1844 to 1855, and elaborate and luminous details, illustrated by diagrams, accompany the report of each officer. Not only are the practical results given, but there is added a mineralogical description of the several ores employed, as well as analyses of their chemical properties. At the same time, the various fluxes are treated of, the constituents of cast-iron given, and although the influence of its associates are yet undecided, yet we are informed a considerable proportion of manganese is said to impart a large, lamellar, and brilliant fracture, and some degree of brittleness; phosphorous is supposed to render iron *"cold short," and sulphur †" hot short." The proportion of

* Brittle when cold.
† do. do. hot

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"total carbon" seems to prove nothing in regard to its influence upon the quality of the metal, though it is imagined that further examination may probably show the reverse. It was found the allotropic carbon increased in the third-class guns, while the combined carbon decreased, and the contrary was to be observed in those of the first-class. Comparative tables are published of the different effects produced upon the metal by the hot and cold blast. Some interesting accounts are given of the several chemical properties of slag, silicium, calcium, magnesium, sodium, potassium, cobalt, nickel, iron, manganese, aluminium, copper, phosphorous, tin, titanium, antimony, and sulphur. Nitrogen in cast-iron having recently been determined, was not searched. The presence of oxygen is doubted as an ingredient of recently-made metal, except in the minute portions of slag accidentally remaining in it, and which sometimes contain a silicate of the oxide of iron. Aridium, which is said to have been found in some Swedish ores, was not observed in the examinations. The report states that it is the policy of Government to prepare for war in time of peace. The enquiry into what may constitute the safest materials for the manufacture of its military arms is one of the most important that can be undertaken; not only is this enquiry applicable to iron for warlike but likewise peaceful purposes. The strongest argument in favour of such an investigation is its own importance and prospective advantages, for the manufacture of iron is the basis and index of modern civilisation, and every effort tending to improve it is a matter of general welfare. Economy is a small consideration as compared with the objects to be attained, and as the undertaking is beyond private means the Government should be the purse-bearer, since it has such a direct interest from the results in the perfection of its own armament. The reports are of great interest to all connected with artillery and the founding of cannon, as well as those concerned in the manufacture of iron generally. It is to be regretted that the British Government did not in

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this country pursue a like train of experiments; had such been the case, in all probability we should have been better prepared in the late struggle. It must be remembered how a false economy had left us so unprovided, that at the commencement of the war our own artillery was in an inefficient state, and if it had not have been for private enterprise our public establishments would have found great difficulties in obtaining the requisite supplies. The lessons of the past will not, however, it is to be hoped, be neglected in the future; and in this instance our transatlantic cousins have followed their favourite maxim of "going-a-head" over the old country.

Captain Norton's Seamless Cartridges.

Sir,—A knowledge of the following fact may be interesting to some of your numerous readers:—When making experiments recently with a strong heavy short rifle of about an inch bore, from some defect where the bottom of the nipple communicates with the interior of the breech, the grains of gunpowder did not rise to the top of the nipple by the action of ramming the wad home—in consequence, the fire of the military percussion-cap frequently failed to fire the charge. But when I made my seamless cartridge with a little fulminating mercury placed within it at the end opposite the shot, and nearest to the bottom of the nipple when in the barrel, the fire of the percussion-cap never failed to fire the cartridge, although the paper of the cartridge was not pierced by any means. A cartridge constructed after this manner is well adapted for breech-loading arms, as it can easily be withdrawn at any time, without being in the least injured, as no grain of the gunpowder can come in contact with the interior of the barrel.—J. NORTON:—*Rosherville, July* 19.

Instructions essential to the proper method of "correcting the Press" extracted from T. C. Hansard's "Typographia."

As it is necessary that Correctors should understand languages, so is it requisite that they should be acquainted with

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the nature of printing, else they will be apt to commit themselves by objections to things done *secundum artem.* It is for this reason that correctors in most printing-houses are chosen out of compositors that are thought capable of that office; and who know how not only to correct literal faults, but who can also discern the improprieties of workmanship, which cannot be expected from gentlemen who have no technical knowledge of printing.

The manner in which errors are noticed in a proof, is by a peculiar set of marks or signs; and in order to illustrate the instructions on this subject, an engraving is subjoined, in which each respective mark is exemplified.

A wrong letter in a word is noticed by drawing a short stroke through it, and making another short stroke in the margin, behind which the right letter is placed. (See plate, and mark 1.*) A *wrong word* is corrected by drawing a line across it, and making the right one in the margin, opposite the faulty line. (See mark 2.)

Where a word or words have been left out, or are to be added to the line, a caret must be made in the place where they are intended to come in, and the word, or words written in the margin.

Where a space is wanting between two words or letters that are intended to be separated, a parallel line must be drawn where the separation ought to be, and the sign 4 placed opposite in the margin. Also, *Where words or letters should join,* but are separated, the mark 5 must be placed under the separation, and the junction of them signified by the same mark in the margin.

When letters or words are set double, or are required to be taken out, a line is drawn through the superfluous word or letter, and the mark 6 placed opposite in the margin.

A *turned letter* is noticed by making a dash under it, and the mark 7 in the margin. Marking turned letters tries a

* It is to be noticed that these fignres are not used to corrections, except occasionally, where, by being very numerous a compositor might be led to mistake one for another; and these corresponding marks used in the lines are applied here only for the purpose of reference to the examples in the plate.

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Corrector's knowledge of the true formation of them, without which it would be better to mark them in the same manner as they do wrong letters, unless they are very sure that they can distinguish b, d, n, o, p, q, s, u, x, z, when they are turned, from where the same letters stand with their nick the right way.

Where a space sticks up between two words, it is noticed by a *cross* in the margin. (See 8.)

Where two words are transposed, the word placed wrong should be encircled, and the mark 9 placed in the margin; but where several words require to be transposed, their right order is signified by a figure placed over each word, and the mark 9 in the margin.

Where a new paragraph is required, a line in the shape of a crotchet should be made, and the same mark 10 placed in the margin; also where a paragraph should not have been made, a line should been drawn from the broken-off matter to the next paragraph, and in the margin should be written, *No break*. (See 11.)

Where several lines or words are to be added, they should be written at the bottom of the page, making a line from the place where the insertion begins, down to those lines or words. (See 12.) But where so much is added as cannot be contained at the foot of the page, write in the margin, *Out, see copy*.

If letters or words are to be altered from one character to another, a parallel line or lines should be made underneath the word or letter, viz. for capitals, three lines; small capitals, two lines; and Italic, one line; and in the margin, opposite the line where the alteration occurs, should be written, *Caps. Small Caps.* or *Ital.* (See 13.)

Where words have been struck out that have afterwards been approved of, dots should be marked under such words, and in the margin should be written, *Stet*. (See 14.)

Where the punctuation requires to be altered, the semicolon, colon, and period, should be marked in the margin and encircled. (See 15.) 16 describes the manner in which the

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hyphen and ellipsis line are marked: and 17, also, the manner in which the apostrophe, inverted commas, the star, and other references, and superior letters, and figures are referred to.

Where letters or lines stand crooked, they are noticed by drawing lines before and after them. (See 18.)

When a letter of a different fount is improperly introduced, it is noticed by the mark, 19.

When corrected, according to these marks, the page will read thus:

"The art of Printing is but three hundred and sixty-five years old; and it long remained an undetermined point between the city of Mentz in Germany, and the city of Haerle.n in Holland, concerning the place where, and the person by whom, this divine art was-first invented and practised; but, at this time, the majority of voices have determined the dispute in favour of Mentz: however, we shall give both their pleas.

"It is said to be first attempted at Mentz, between the years 1440 and 1450, by John Fust, or Faust, John Meydenbuch, and John Genesteisch surnamed Guttemburg.

"It was a question long controverted by many learned antiquarians, whether Guttemburg or Faust was the inventor of that art, till happily the original instrument was found; whereby it appears, that the latter only connected the others with him for the sake of their purses, he not being able to proceed without, on account of the great expenses attending the cutting of the blocks of wood; which, after they were once printed from, became entirely useless for any other work. This *instrument,* which is dated Nov. 6, 1455, is decisive in favour of GUTTEMBERG; but the honor of single types, made of metal, is ascribed to Faust, wherein he received great assistance from his servant and son-in-law, Peter Schoeffer, who," &c.

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An Exemplification of Typographical Marks

"THE art of Printing is but three hundred
and sixty five years old; end it long remained [1] a/
an undetermined point between the ~~town~~ of [2] city/
Mentz in Germany, and ‸ City of Haerlemin [4] # / [3] the
Holland, concerning the place where, and the
per son by whom, this divine art was first [5] ⁀
invented and practised; but, ~~but~~, at this time, [6] ₰/ /[6] ₰
the majority of voices have determined the [7] 9
dispute in favor of Mentz; however, we shall [8] ⊥
give both their pleas.

"It is said to be first ‸at Mentz attempted [9] tr/
between the years 1440 and 1450, by John
Fust, or Faust, John Meydenbuch, and John
Genesteisch, surnamed Guttemberg. [It was a [10] [/
long[2] controverted[3] question[1] by many learned [9] tr./
antiquarians | whether Guttemberg or Faust ,/
was the inventor of that art, till happily the
original instrument was found. [11] no break/
Whereby it appears, that ‸on account of
the great expences attending the cutting of
the blocks of wood; which, after they were ft/
once printed from, became ~~entirely~~ useless for [14] stet/
any other work. This instrument which is [13] Ital./
dated Nov. 6. 1455 is decisive in favor of [13] S. Caps./
Guttemberg; but the honor of single types [13] Caps./
made of metal is ascribed to Faust| wherein [15] ; : .
he received great assistance from his servant
and son-in law Peter Schoeffer who," &c. [16] // H / [17] ' / [19] of

[12] the latter only connected the others with him for the sake of their purses, he not being able to proceed without.

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RIFLED ORDNANCE.

Mr. Bashley Britten's Invention.

(Continued from page 394.)

REMARKS ON THE REPORT OF THE ORDNANCE SELECT COMMITTEE,

DATED 19TH JUNE, 1856.

The following is the conclusion arrived at in this Report:—

"Sufficient has now been done to give strong grounds for believing that Mr. Britten's shot for rifled guns are inferior *in several respects* to others under trial."

This decision, the terms of which seem to be carefully qualified, is based upon a comparison between the results of Mr. Britten's uncompleted experiment of the 2nd June with experiments made with the projectiles of three other inventors, particulars of which are given in the Report.

Without wishing to detract from the merit of these competing inventions, Mr. Britten desires that this comparison may be made impartially, and he has therefore extracted the figures quoted by the Committee, and placed beside them the results of the trials of his projectile.

	Description of Gun.	Weight of Shot.	Charge of Powder	RANGE. Medium Elevations.	RANGE. High Elevations.
		lb.	lb.	yards.	yards.
Wahrendorff's Shot....... ...	Breech Loading.......	64	not stated	1950, at 5 deg.	3700, at 12 deg.
Lawrence's Soft Metal Shot..........	68-pr block, 95 cwt.	77	12	2509, at 5 deg.	—
		77	16	2595, at 5 deg.	4097. at 10 deg.
Jeffery's Compound Shot.	56-pr. do. 87 cwt.	51	6	1848, at 4 deg.	—
		51	8	2550, at 6 deg.	—
		51	10	....	3550, at 10 deg.
Britten's Percussion Shells.........	32-pr. 56 cwt. altered Service Gun.........	50	5½	2390, at 5 deg.	—
	9-pr. 17 cwt. altered Service Gun.........	14	1¾	* 2052, at 5 deg.	†3113, at 10 deg.
		14	1¾	....	3620, at 12 deg.

The Report states:—

"From a due consideration of the *above* experiments with rifled guns, the Committee are decidedly of opinion that no further trials ought to be made with projectiles supplied by Mr. Britten."

* An average of five rounds. † An average of nine rounds.

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It is for any dispassionate judge to say whether this is a just inference to be deduced from the above figures.

Regarding only the question of range, it will be seen that Lawrence's soft metal shot was the only one that actually commanded a greater distance than Britten's shell. In this case a 95 cwt. gun is compared with one of 56 cwt., and with *sixteen pounds of powder*, it had 205 yards longer range at 5° than the smaller gun with 5½ *lb. of powder.*

Wahrendorff's shot had no less than 440 *yards less range* at 5° than Britten's shell. Jeffery's shot from an 87 cwt. gun had also less range than Britten's percussion shells from the 56 cwt. gun. The average of five rounds of Britten's shells from a 9-pr. gun of 17 cwt., with only 1¾ lb. of powder, equalled the range of Jeffery's shot from the heavy gun at medium elevations; and at 10°. Taking an average of nine rounds, it was only 437 yards less than Jeffery's shot from *a gun of five times the weight,* and with a charge of nearly *six times the quantity of powder.*

The Report deals only with the question of Range, but there are other points which must be borne in mind. The Committee make no allusion to the fact that Britten's shells can, from their construction, be made *at much less cost* than the other shot, and also that Lawrence's and Jeffery's shot, being composed—one entirely, and the other chiefly—of soft metal, would be far less effective against stone walls. No notice is taken of Britten's shells having been fired from *an ordinary service gun* converted into a rifle, while the other guns had to be made expressly of double the usual strength.

The Committee also pass over the very important fact that Britten's projectiles are SHELLS while the others are only *shot.* That as shells they would be far more destructive, especially as they combine the important property of exploding with certainty at the instant of striking; this in itself having long been a desideratum in the service. Besides this, they might, on special occasions, be used effectively as shells from long guns at high elevations, so that a vertical fire,

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with a range of 6000 or 7000 yards, might be acquired. At the same time the construction of these shells is such, that when used empty for battering or breaching, at short ranges, they would be no more liable to have their effect destroyed by breaking from the concussion than the ordinary solid shot. If these several points have accidentally escaped the Committee's attention, Mr. Britten hopes that they may not be lost sight of.

The cause of the failure of six out of the seven shells recently fired, has been clearly pointed out and must be as obvious to the Committee as the remedy for it.

That the "very great discrepancy in the range of each shot," alluded to in the Report, cannot be attributed to the principle on which the shells are constructed, Mr. Britten believes will be evident from an examination of the following particulars of the three preceding experiments. With the exception of seven shells, which failed from being ill constructed, *all the rounds* fired on these occasions are included.

They are not to be regarded as affording perfect results, for several changes were made in the several experiments, in order to determine the best method of applying the invention. But notwithstanding all the errors which Mr. Britten made in conducting these trials, he is informed by eminent artillerists, that he may confidently appeal to the following Table, as affording an example of gunnery practice which has hitherto been unapproached for length of range, accuracy of fire, and general effect.

Mr. Britten is most anxious to be allowed the opportunity of fully maturing this invention for the public service, and will be happy to render his assistance to the Military authorities for this purpose; he respectfully declines however to allow it to be taken out of his hands at the present stage, and the invention, being secured by a patent, cannot legally be used by any one without his concurrence.

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Particulars of Experiments made at Shoeburyness, 26, August 22, and October 23 and 24, 1855, BASHLEY BRITTEN's Percussion Shell from a Rifl pounder Iron Service Gun of 17 cwt.

Elevation of Gun.	Weiget of Shell.	Charge of Powder.	Recoil.	Deflection from Line of Aim.	Range First Graze.	
	lb.	lb.	fit. in.		yards.	
5 Degrees, Range of service 9 lb. shot with 3 lb. pr.					1650	
do... ..	11	2	4 0	36 yards left.	1720	26
do... ..	11	2	4 0	15 — right.	2225	26
do... ..	14	1¾	4 4	3 — do.	1920	26
do... ..	14	2	5 10	8 — left.	2075	26
do... ..	14	1¾	4 1	11 — right.	1875	22
do... ..	14	2	4 7	10 — do.	1880	22
do... ..	15	1¾	4 4	17 — do.	1752	24
do... ..	15	1¾	4 3	10 — do.	1775	24
do... ..	15	1¾	4 4	20 — do.	1760	24
do... ..	15	1½	4 3	12 — do.	1825	25
do... ..	15	1¾	4 9	24 — left.	1940	25
do... ..	15	2	5 4	16 — do.	2100	25
10 Degrees, Range of service 9 lb. shot with 3 lb. pr.					2240	
do... ..	11	2	4 7	59 yards right.	3150	26 J
do... ..	14	1¾	4 10	10 — do.	3225	26 J
do... ..	14	2	5 10	13 — do.	3275	26 J
do... ..	14	2¼	6 3	42 — do.	3065	26 J
do... ..	14	1¾	3 9	13 — do.	2710	22 A
do... ..	14	1¾	3 2	26 — do.	2820	22 A
do... ..	15	1½	....	45 — do.	† 2745	24 O
do... ..	15	1¾	4 0	44 — do.	3053	24 O
do... ..	15	1¼	4 1	48 — do.	† 2775	24 O
do... ..	15	2	4 0	51 — do.	3060	24 O
do... ..	15	1¾	5 6	10 — do.	2780	25 Oc
do... ..	15	1¾	5 6	10 — do.	2945	25 Oc
do... ..	15	1¾	5 9	In line. *	3025	25 Oc
do... ..	15	1¾	5 9	1 yard left. *	3140	25 Oc
do... ..	15	2	6 4	36 — right. *	2700	25 Oc
do... ..	15	1¾	6 3	24 yds. left. *	3020	25 Oc
12 Degrees	15	1¾	....	32 — left. *	3150	25 Oct.
do.	15	1¾	....	4 — do. *	3400	25 Oct.
11½ Degrees	14	1¾	....	28 yards right.	3155	22 Aug.
do.	14	2	4 1	38 — do.	2905	22 Aug.
12 Degrees	14	1¾	4 10	12 — do.	3620	26 July.

N. B.—The above comprise *all the rounds* fired at th several trials, with the exception of seven shells, which faile from ill construction. There was some alteration of th shape of the shells on each day they were tried, and this wil account for the different results on each occasion.

* In these six rounds the Gun was laid to the left, so as to allow for the deflection to the right.
† These shells were fired with some wooden bottoms, which lessened the range.

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My dear ———

As an idle man; having nothing to do; I send you the following to raise a smile, if nothing more; and to shew you the progress of purity of ideas, if nothing else, on Artillery matters.

The Art of War

and the way that it is at present praatised in France.

Written in French by Louis de Guya, an expert Officer of the French Army, and dedicated to his most Christian Majesty.

Translated for Public satisfaction and advantage.

LONDON

PRINTED FOR ROBERT HARFORD AT THE SIGN OF THE ANGEL IN CORNHILL, NEAR THE ROYAL EXCHANGE.

1678.

CHAPTER XVII.

OF THE ARTILLERY AND ITS OFFICERS.

The Artillery is a provision of all Armes, and Instruments that are necessary for War, such as are Canons and their Carriages; Bullets—Bombs—Morter Pieces—Petards—Granados—Cartridges—Barrels of Powder—Ball and Match—Saucissons—Red hot Bullets—Godrons—Pitched Faggots stuffed with Granados—All kinds of Arms—Hatchets—Sawes—Shovels—Pick-axes—Wedges—Ladders of wood and rope—Beams—Joysts—Planks—Tuns or Hogsheads—Ropes—Pontoons for Boats or Bridges; and all sorts of Artificial Fire.

OF COMMISSARIES.

Every Piece in a Battery hath its Commissary and Officers to serve it.—A Commissary must be bold, skilful, and experienced; because he it is that levels the Piece by means of the Viser and Wedges, which he causes to be raised or lowered as much as he thinks convenient, according as he knows how the Pieces carry, and what their burden is.

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Of Gunners.

Every piece in a Battery ought to have its Gunner as well as Commissary, the duty of the Gunner is, so soon as the Piece hath fired, to cool it with a sponge dipped in Vinegar or Urine; without losing of time, to put in the Powder—Wad and Shot.—Two of those that serve the Gun take care to place the Piece again into his Place; the Commissary levels it, and gives order to fire.

A Gunner who understands his Trade well, has special care not to put the Powder into a Piece that has just fired until he hath first cooled it; because of the Heat, that remains long in the Metal. Every Piece ought to have its men to serve it; its store of Powder and Bullets of size, with a provision of Hay for Wads, but in suce a place as no sparks can come to.

One more Extract and I have done.

Of Corporals—Lanspassades; and other inferiour Officers of a Company.

Every Company should have a Surgeon, commonly called Frater; to dress the Sick and Wounded, and Shave the Souldiers, being as a Mate to the Surgeon Major of the Regiment; he ought to make Provision of Medicaments proper to stop Bleeding, hinder Inflamation and ease Pains.

Yours sincerely,

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On the Manufacture of Iron and Steel without Fuel.

By Mr. W. Bessamer.

(From the Athenæum, August 23.)

Mr. Bessamer asserted that crude iron contains about 10 per cent. of carbon; that carbon cannot exist at white heat in the presence of oxygen, without uniting therewith and producing combustion, that such combustion would proceed with a rapidity dependent on the amount of surface of carbon exposed; lastly, that the temperature which the metal would acquire would be also dependent on the rapidity with which the oxygen and carbon were made to combine, and consequently that it was only necessary to bring the oxygen and carbon together in such a manner that a vast surface should be exposed to their mutual action in order to produce a temperature hitherto unattainable in our largest furnaces. With a view of testing practically this theory, he had constructed a cylindrical vessel of three feet in height, somewhat like an ordinary cupola furnace, the interior of which was lined with firebricks; and at about two inches from the bottom of it inserted five tuyere pipes, the nozzles of which were framed of well-burnt fire-clay, the orifice of each tuyere pipe being about three-eighths of an inch in diameter. These were so put into the brick lining (from the outer side) as to admit of their removal and renewal in a few minutes when they were worn out. At one side of the vessel, about half way up from the bottom, there was a hole made for running in the crude metal, and on the opposite side there was a tap-hole stopped with loam, by means of which the iron was run out at the end of the process. The vessel should be placed so near to the discharge-hole of the blast furnace as to allow the iron to flow along a gutter into it. A small blast cylinder would be required, capable of compressing air to about 8 lb. or 10 lb. to the square inch. A communication having been made between it and the tuyeres before named, the converting vessel

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would be in a condition to commence work. It would, however, on the occasion of its being first used after relining with fire-bricks, be necessary to make a fire in the interior with a few baskets of coke, so as to dry the brick-work and heat up the vessel for the first operation, after which the fire would have to be all carefully raked out at the tapping-hole, which would again be made good with loam. The vessel would then be in readiness to commence work, and might be so continued without any use of fuel, until the brick lining in the course of time became worn away and a new lining was required. The tuyeres are situated nearly close to the bottom of the vessel; the fluid metal will therefore rise some eighteen inches or two feet above them. It is necessary, in order to prevent the metal from entering the tuyereholes, to turn on the blast before allowing the fluid crude iron to run into the vessel from the blast furnace. This having been done, and the fluid iron run in, a rapid boiling up of the metal will be heard going on within the vessel, the metal being tossed violently about, and dashed from side to side, shaking the vessel by the force with which it moves from the throat of the converting vessel. Flame will then immediately issue, accompanied by a few bright sparks. This state of things will continue for about 15 or 20 minutes, during which time the oxygen in the atmospheric air combines with the carbon contained in the iron, producing carbonic acid gas, and at the same time evolving a powerful heat. Now, as this heat is generated in the interior of, and is diffused in innumerable fiery bubbles through the whole fluid mass, the metal absorbs the greater part of it, and its temperature becomes immensely increased; and by the expiration of the 15 or 20 minutes before named, that part of the carbon which appears mechanically mixed and diffused through the crude iron has been entirely consumed. The temperature, however, is so high, that the chemically-combined carbon now begins to separate from the metal, as is at once indicated by an immense increase in the volume of flame rushing out of the throat of the vessel.

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The metal in the vessel now rises several inches above its natural level, and a light frothy slag makes its appearance, and is thrown out in large foam-like masses. This violent eruption of cinder generally lasts 5 or 6 minutes, when all further appearance of it ceases—a steady and powerful flame replacing the shower of sparks and cinder which always accompanies the boil. The rapid union of carbon and oxygen which thus takes place adds still further to the temperature of the metal, while the diminished quantity of carbon present allows a part of the oxygen to combine with the iron, which undergoes combustion, and is converted into an oxide. At the excessive temperature that the metal has now acquired, the oxide, as soon as formed, undergoes fusion, and forms a powerful solvent of those earthy bases that are associated with the iron. The violent ebullition which is going on mixes most intimately with scoriæ and metal, every part of which is thus brought into contact with the fluid, which will thus wash and cleanse the metal most thoroughly from the silica and other earthy bases which are combined with the crude iron, while the sulphur and other volatile matters which cling so tenaciously to iron at ordinary temperatures are drawn off, the sulphur combining with the oxygen, and forming sulphurous acid gas. The loss in weight of crude iron during its conversion into an ingot of malleable iron, was found, on a mean of four experiments, to be 12½ per cent., to which will have to be added the loss of metal in the finishing rolls. This will make the entire loss probably not less than 18 per cent., instead of about 28 per cent., which is the loss on the present system. A large portion of this metal is, however, recoverable, by treating with carbonaceus gases the rich oxides thrown out of the furnace during the boil. These slags are found to contain innumerable small grains of metallic iron, which are mechanically held in suspension in the slags, and may be easily recovered, by opening the tap-hole of the converting vessel, and allowing the fluid malleable iron to flow into the iron ingot moulds placed there to receive it.

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The masses of iron thus formed will be perfectly free from any admixture of cinder, oxide, or other extraneous matter, and will be far more pure and in a sounder state of manufacture than a pile formed of ordinary puddle bars. And thus it will be seen that by a single process, requiring no manipulation or particular skill, and with only one workman, from three to five tons of crude iron passes into the condition of several piles of malleable iron in from 30 to 35 minutes, with the expenditure of about one-third part the blast now used in a fiery furnace with an equal charge of iron, and with the consumption of no other fuel than is contained in the crude iron. To persons conversant with the manufacture of iron (said Mr. Bessamer), it will be at once apparent that the ingots of malleable metal which I have described will have no hard or steely parts, such as are found in puddled iron, requiring a great amount of rolling to blend them with the general mass; nor will such ingots require an excess of rolling to expel cinder from the interior of the mass, since none can exist in the ingot, which is pure and perfectly homogeneous throughout, and hence requires only as much rolling as is necessary for the development of fibre; it therefore follows that, instead of forming a merchant bar or rail by the union of a number of separate pieces welded together, it will be far more simple and less expensive to make several bars or rails from a single ingot. Doubtless this would have been done long ago had not the whole process been limited by the size of the ball which the puddler could make. I wish to call the attention of the meeting to some of the peculiarities which distinguish cast steel from all other forms of iron—namely, the perfect homogeneous character of the metal, the entire absence of sand-cracks or flaws, and its greater cohesive force and elasticity, as compared with the blister steel from which it is made—qualities which it derives solely from its fusion and formation into ingots, all of which properties malleable iron acquires in a like manner by its fusion and formation into ingots in the new process; nor must it be forgotten that no

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amount of rolling will give to blister steel (although formed of rolled bars) the same homogeneous character that cast steel acquires by a mere extension of the ingot to some ten or twelve times its original length. One of the most important facts connected with the new system of manufacturing malleable iron is, that all the iron so produced will be of that quality known as charcoal iron; not that any charcoal is used in its manufacture, but because the whole of the processes following the smelting of it are conducted entirely without contact with or the use of any mineral fuel; the Iron resulting therefrom will in consequence be perfectly free from those injurious properties which that description of fuel never fails to impart to iron that is brought under its influence. At the same time this system of manufacturing malleable irons offers extraordinary facility for making large shafts, cranks, and other heavy masses. It will be obvious that any weight of metal that can be founded in ordinary cast iron by the means at present at our disposal may also be founded in molten malleable iron, to be wrought into the forms and shapes required, provided that we increase the size and power of our machinery to the extent necessary to deal with such large masses of metal. A few minutes reflection will show the great anomaly presented by the scale on which the consecutive processes of iron making are at present carried on. The little furnaces originally used for smelting ore have been from time to time increased in size until they have assumed collosal proportions, and are made to operate on two or three hundred tons of materials at a time, giving out ten tons of fluid metal at a single run. The manufacturer has thus gone on increasing the size of his smelting furnaces, and adapting to their use the blast apparatus of the requisite proportions, and has by this means lessened the cost of production in every way. His large furnaces require a great deal less labour to produce a given weight of iron than would have been required to produce it with a dozen furnaces; and in like manner he diminishes his cost of fuel blast and repairs, while he insures a uni-

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formity in the result that never could have been arrived at by the use of a multiplicity of small furnaces. While the manufacturer has shown himself fully alive to these advantages, he has still been under the necessity of leaving the succeeding operations to be carried out on a scale wholly at variance with the principles he has found so advantageous in the smelting department. It is true that hitherto no better method was known than the puddling process, in which from 400 lb. to 500 lb. weight of iron is all that can be operated upon at a time; and even this small quantity is divided into homœopathic doses of some 70 lb. or 80 lb, each of which is moulded and fashioned by human labour, and carefully watched and tended in the furnace, and removed therefrom one at a time, to be carefully manipulated and squeezed into form. When we consider the vast extent of the manufacure, and the gigantic scale on which the early stages of the process is conducted, it is astonishing that no effort should have been made to raise the after processes somewhat nearer to a level commensurate with the preceding ones, and thus rescue the trade from the trammels which have so long surrounded it. Before concluding these remarks, I beg to call your attention to an important fact connected with the new process which affords peculiar facilities for the manufacture of cast steel. At that stage of the process immediately following the boil, the whole of the crude iron has passed into the condition of cast steel of ordinary quality. By the continuation of the process the steel so produced gradually loses its small remaining portion of carbon, and passes successively from hard to soft steel, and soft steel to steely iron, and eventually to very soft iron; hence, at a certain period of the process, any quality of metal may be obtained. There is one in particular, which, by way of distinction, I call semi-steel, being in hardness about midway between ordinary cast steel and soft malleable iron. This metal possesses the advantage of much greater tensile strength than soft iron. It is also more elastic, and does not

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readily take a permanent set, while it is much harder and is not worn or indented so easily as soft iron. At the same time it is not so brittle or hard to work as ordinary cast steel. These qualities render it eminently well adapted to purposes where lightness and strength are especially required, or where there is much wear, as in the case of railway cars, which from their softness of texture soon become destroyed. The cost of semi-steel will be a fraction less than iron, because the loss of metal that takes place by oxidation in the converting vessel is about two and a-half per cent. less than it is with iron; but as it is a little more difficult to roll, its cost per ton may be fairly considered to be the same as iron. But as its tensile strength is some thirty or forty per cent. greater than bar iron, it follows that for most purposes a much less weight of metal may be used; so that taken in that way the semi-steel will form a much cheaper metal than any that we are at present acquainted with. The facts which I have brought before the meeting are not mere laboratory experiments, but the result of working on a scale nearly twice as great as is pursued in our largest iron works—the experimental apparatus doing 7 Cwt. in thirty minutes, while the ordinary puddling furnace makes only 4½ Cwt in two hours, which is made into six separate balls, while the ingots or blooms are smooth, even prisms, ten inches square by thirty inches in length, weighing about equal to ten ordinary puddle balls*

The Iron Manufacture and Mr Bessemer's Invention.

(From the *Birmingham Journal.*)

The interest which has been excited by the improvement recently proposed in the manufacture of iron and steel by Mr. Bessemer, and the vast importance to the country in general, and especially to this neighbourhood, of the manu-

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* Bombay Times 27th September 1856.

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facture in question, render it unnecessary that we should apologize to our readers for occupying their attention with some remarks on the iron manufacture. In order that those whose studies or avocations have left them unacquainted with the general nature of this interesting manufacture may the better comprehend the exact bearings of a process which is exciting an attention unparalled in modern times, we will give such a brief sketch of the process of manufacturing iron as will enable them, generally at all events, to estimate the importance of Mr Bessemer's invention.

Iron is the most extensively distributed of the metals. It exists largely both in the mineral and organic kingdoms, being a constituent of an immense number of natural minerals, and existing as an essential element in the blood of vertebrate animals. The minerals from which iron may be extracted are numerous; but we will only notice those which are important in the British Isles. Peroxide of iron (consisting of 56 parts by weight of iron, combined with 24 parts of oxygen) constitutes the mineral called red hæmatite, of which large quantities exist in Lancashire, Cornwall and elsewhere.

This ore is used in England principally for mixing with other ores, but in Sweden and Russia Iron is made from it direct. In France brown hæmatite (a hydrated peroxide of iron, a mineral of the same composition as the last described, but containing water) is much used in the manufacture of iron. But it is the clay ironstone which yields the enormous supply of iron produced in Great Britain. This ore is an impure carbonate of iron, containing about 30 per cent on an average of pure iron. Pure carbonate of iron consists of 28 parts by weight of iron, and eight parts of oxygen (oxyde of iron), combined with six parts of carbon and 16 of oxygen (carbonic acid). The pure carbonate of iron is in clay, iron ore mixed with clay, oxide of manganese, lime, and magnesia.

The extraction of the metal from this compound is effected by a process, the general principles of which are very

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simple. First, the ore is roasted; that is to say, it is made into heaps with coal, and ignited; the carbonic acid and water of the mineral are driven off, and the ore is left in a porous state, favourable to the subsequent processes. We may regard the roasted ore as an impure oxide of iron, containing, of course, all the earthy matter, and whatever was not volatile in the native mineral. If we reflect for a moment on what we have to accomplish in order to obtain the iron from this compound, we shall soon be able to devise the means of doing it. We have iron combined with oxygen, and we wish to separate the latter from the former, so as to leave the metal free. How shall we accomplish this? Clearly only by presenting something to the compound which has a higher affinity for oxygen than iron has. What is this? It is charcoal or carbon. This element, so inert at ordinary temperatures as to be the most imperishable of things, assumes, when heated strongly, an affinity for oxygen more powerful than that of any other known substance; and there are few metallic oxides which do not yield oxygen to carbon at an elevated temperature, and thus liberate the metal in a reguline or metallic state. This process of depriving metallic oxides of their oxygen is called reduction, and the reduction of the ores of iron, copper, lead, zinc, &c., consists mainly in heating them, after suitable preparation with carbon, and thereby deoxidizing them. To reduce the iron, then, we have only to heat it with charcoal. But since the ore contains a large quantity of earthy matter, the particles of iron, when reduced, would be held in this porous earthy mass, like water in a sponge, and, although reduced, the metal would remain in an unavailable form. How can we separate the metal from the earthy matter? Not by mechanical but by chymical means. If we mix with the ore something which will form a readily fusible compound with the earthy matter, that earthy matter will liquify, and the particles of melted iron will fall through the liquid, and collect together into a mass. Lime is used for this purpose. It is as though a sponge filled with

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water dissolved on the application of gentle heat, the water in the sponge forming the lower stratum, and the matter of the sponge itself a light oily liquid floating on the water. Our readers will now have a general notion of the process which they see carried on so extensively in the neighbouring iron districts. Into huge towers which stud the country, thick almost "as leaves in Valambrosa" day and night, and from year's end to year's end, toiling engines pour thousands of tons of the materials we have enumerated—iron ore, coke, and lime. Blast engines force streams of compressed air into the ignited materials, and the mass slowly sinking in the tower melts into two strata, the one the slag, the other the iron. The former flows off from an under opening, and the latter is drawn off at intervals from holes made in the lower part of the furnace. The molten metal is conducted along channels made in sand, and slowly filling rough moulds connected with these channels gradually solidifies, and constitutes the pig iron of commerce. Let us pause awhile to ask our readers if they have ever seen the tapping of a blast furnace at night? If they have not we tell them that within an hour's journey there is a sight the beauty and majesty of which they have no conception. The appearance of the furnace alone is impressive. The huge flames struggling up, like the panting breath of an imprisoned monster, lighting up the heavens with their fitful glare, and keeping time in their flickering with the groaning blast with which the fire is urged, form a picture which when examined near will not be soon forgotten. But what can compare with the beauty of the casting process? It is night; and the eye sees not the beautiful network of moulds with which the earth is covered. The furnace is tapped and out gushes the liquid fire; quietly at first, and afterwards more slowly, it finds its way into the various ramifications of the impressed sand, and in a few minutes the whole ground is covered with glowing fire streams. But let us approach. Hark! How the stream hisses as it travels on! And see, thousands and thousands of bright a-

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toms shoot into the air from the surface of the metal, burn with a beautiful scintillation, and fall hissing down "a hailing fount of fire."

But to return to our facts. The coke, we have seen, constitutes both the fuel from which the necessary heat is produced, and the reducing agent, by which the oxide of iron is deoxidized; the lime makes the earthy matter fusible, and enables the iron to separate itself therefrom. If our object were to give a somewhat full account of the iron manufacture we should stop here to discuss the many important questions which present themselves at this point—The enormous quantity of air which each day is poured through these huge furnaces, the deeply interesting chymical changes which it undergoes as it filters through the fiery column, and the remarkable products which have yielded themselves at its exit, to the researches of Bunsen, Playfair, and others; the prodigious quantity of heat which is carried off by the blast of cold air, and the economy which has resulted from the heating of the air before its introduction into the furnace; the change in the fuel which has followed the use of the hot blast, and the change in the characters of the iron produced, which has followed that; the modifications in the lime flux which different ores require, and the consequences which result from a too fusible or too infusible a slag; the objects to be attained by the mixture of ores, and the necessity for the application of minute chymical knowledge to the perfecting of a manufacture so simple in general principle, so obscure in its details; but all these things we must leave unnoticed, and confine ourselves to such particulars as have a direct bearing on the process proposed by Mr Bessemer.

The method of manufacture we have roughly described produces iron, but not pure iron; that has never been produced but by the chymist, and but few eyes have ever seen it. The iron produced is cast iron, which consists mainly of iron, but is contaminated with a great variety of impurities,

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from which it is difficult to free it. Just as in the fermenting of grape juice the principal change is the conversion of sugar into carbonic acid and alcohol, during the occurrence of which sundry small decompositions and transformations take place, giving rise to products on which the flavour or *bouquet* of the wine depends; so, in the reduction of iron from its ore, although we obtain a product containing perhaps 95 per cent. of iron, the remaining 5 per cent. consists of a long array of foreign ingredients, all existing in some form of combination in the materials employed; these have been so affected during the reduction of the iron as to have assumed a state in which they could combine with iron, and hence we discover that the iron drawn from the furnace is invariably contaminated with them. Although small in quantity, the effect which these impurities have upon the physical properties of the iron is truly wonderful. One per cent. of phosphorus or a scarcely larger proportion of sulphur, has a most prejudical effect upon the iron containing it. The principal element which, in the blast furnace, enters into combination with iron is carbon or charcoal. The metal is capable of combining with 5 per cent. of its weight of carbon, and many kinds of cast iron contain nearly this quantity. Steel is a compound of iron and carbon, containing less carbon than cast iron; and the production of steel from cast iron is simply the removal of a portion of the carbon.

If cast iron from the blast furnace consisted of iron and carbon only, the production of steel and wrought iron therefrom would be easily effected; but cast iron contains, besides iron and carbon, the following impurities, some or all of them: silicon, sulphur, phosphorus; and in minute quantity, aluminum, calcium, and potassium. The conversion of cast iron into wrought iron consists in the removal of these impurities. This purification consists in the ordinary manufacture, in submitting the iron to the action of air, and also to a mechanical kneading and squeezing process; these are effected

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in the refinery and in puddling, and it is these processes which Mr. Bessemer proposes to supersede by his invention.

We ask the reader's careful attention to the following:—namely, that the impurities in cast iron consist of substances all of which combine with oxygen at a high temperature; carbon forming carbonic acid; sulphur, sulphurous acid; phosphorus, phosphoric acid; silicon, silicic acid; (silica, or the matter of sand); and so of the rest. Now, the exposure of the cast iron to heat and air (containing oxygen) is sufficient to cause the substances to form oxygen compounds, either volatile or easily fusible and incapable of entering into combination with metallic iron. But since these impurities are diffused in small quantity through the mass of the iron, it is with great difficulty that air can be brought to act upon them. This, however, is done efficiently, but at great trouble—first in the refinery, and afterwards more completely in the puddling process. The melted cast iron is exposed in the refinery to a strong heat, in contact with air, and a large proportion of the carbon contained in the iron is burnt off, as carbonic oxide; the silicon becomes oxidized as silicic acid (silica), and the iron also oxidizing, supplies a base (oxide of iron), with which the silicic acid combines. This compound constitutes the slag, which is formed in the process. The action of the slag itself upon the impurities yet contained in the iron is a most interesting chymical phenomenon, and will be noticed hereafter. Where a very superior iron is required, charcoal is used in this process instead of coke; and the iron so made is called "charcoal iron." The impurities contained in ordinary coke are in part communicated to the iron, and injure its quality. The minute details of the refinery we need not describe.

The iron thus partially purified is next puddled. It is fused on the bed of a reverberatory furnace, and vigorously stirred about, so as to expose it to the action of the air, oxygen is rapidly absorbed, and the gaseous carbonic oxide formed es-

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capes in bubbles, giving the appearance of boiling, and burning at the surface with a blue flame. As the carbon is burnt off, the fusibility of the mass diminishes, and although the heat is increased as the process proceeds, the molten metal passes from a fluid to a spongy, semifluid mass. The fearful labour of the puddler now commences. He approaches the furnace almost in a state of nudity, and on the end of an iron bar collects from the bed of the furnace as much iron as he can lift. This ball, or "bloom," he swings through the air under a forge hammer, or other compressing machine. The blows at first crush the soft mass like dough, sending out showers of sparks, and squeezing liquid drops from the interior of the metal. The ball cools, the blows of the hammer now ring, the fire shower grows faint, and the liquid drops are replaced by scaly masses, which fall from the now almost solid metal. The kneading process is continued by passing the metal between rolls, in the grooves of which it is drawn out and compressed; it is doubled up and rolled, and heated and doubled up, and rolled again. Have you never seen as you travelled by railway or otherwise at night, the mouth of a black furnace opened on a sudden, sending a ray, as of sunlight, athwart the sky, and disclosing something within "so blinding white, so blasting bright," that the eye closed involuntarily? If you returned leisurely to the sight, you observed half naked men darting across the light beams, their motions seemingly more capricious and more sudden than the dancing of the images in a phantasmagoria. In a stray beam of the quivering light you see now and then the heavy rocking head of the steam engine and the greasy teeth of the cogwheels shoot by, brighter than rows of pearls or falling water drops; the blows of the forge hammer shake the earth; and the whirring of the wheels makes you giddy. What is all this? It is puddling; the conversion of cast iron into wrought iron.

The metal so obtained is not pure, but it is sufficiently so for commercial purposes. It contains carbon, silicon,

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and other impurities, but in quantities so minute as not to affect its physical properties materially. It is a curious fact, worth here noting, that some of these impurities which have a most pernicious effect upon iron do not injure it in direct proportion to their quantity; but preserve their injurious action down to a certain point only, and below that proportion appear to be wholly inoperative.

The elimination of carbon, and the other impurities contained in cast iron, and its consequent conversion into wrought iron, takes place by virtue of that beautiful chymical process called cementation—a process in which a chymical change is propagated through a solid or nearly solid body from the exterior inwards, or the reverse. This process is beautifully illustrated by the annealing of cast iron, or the production of malleable iron articles, so largely practised in Birmingham and its neighbourhood. Small articles made of cast iron are imbedded in powdered peroxide of iron, and heated for many hours, or days. The oxygen in the oxide of iron combines with the carbon of the cast iron, and withdraws it; in short, burns the carbon. This removal of the carbon, commencing at the surface, gradually proceeds inwards, until the whole substance of the article has been decarbonized, and the cast iron converted into soft, wrought iron, without the article having changed its form. The converse takes place in the manufacture of steel. In this case the wrought iron is heated with carbon, and the combination of the latter with the former, commencing at the surface slowly penetrates the mass.

In precisely the same way are the carbon and other impurities removed from cast iron in its conversion into wrought iron; the slag containing oxide of iron playing a most important part. The air can only act superficially on a large mass of fused iron, even when it is kept in motion; but the oxide formed superficially is mixed with the mass of the metal, and yields oxygen to the carbon, and other mat-

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ters in its interior. The silicon becomes converted into si-lica, which dissolves more oxide, and the carbon into carbo-nic oxide, which bubbles and burns as described. During the puddling and hammering, or shingling, and piling of the iron, the slag is first thoroughly incorporated with, and, hav-ing effected its work, squeezed from, the mass of iron.

Can these impurities be removed without this labour, time, and fuel ? The production of wrought iron direct from the ore can unquestionably be effected, and, where wood charcoal can be employed in the place of mineral fuel, perhaps eco-nomically. It is commonly done in the bloomery forges of America, and the Catalan forges of the Pyrenees ; and these processes are but ameliorations of the earliest and rudest me-thods of making iron. Mr Bessemer proposes to effect the same object by the use of air alone. He forces air into the fused cast iron in large quantity ; the temperature rises very high, and the iron is said to be converted into wrought iron. The heat produced is thought to arise from the com-bustion of the carbon, the whole of which, together with the other impurities, is removed. It is surprising that the car-bon, the maximum quantity of which is five per cent., should burn so rapidly as to produce the great heat described ; and we wait anxiously for such accurate experiments as shall prove that the iron itself is not largely oxidized. It will al-so be most interesting both to the manufacturer and the chymist to learn that the slag can be perfectly removed from the mass of the iron without resorting to the mechanical treatment we have described. We can readily imagine that Mr Bessemer may reduce the percentage of carbon so low by his process as to make the iron approximate in composi-tion to steel. This has been done three quarters of a centu-ry ago ; and the patent lists show that from 1771 to the pre-sent day, scores probably, of patents have been taken out for making steel direct from the ore. To effect this, however, is to do but little ; what is wanted is not steel of an indiffe-rent quality, but iron, from which the carbon has been so far

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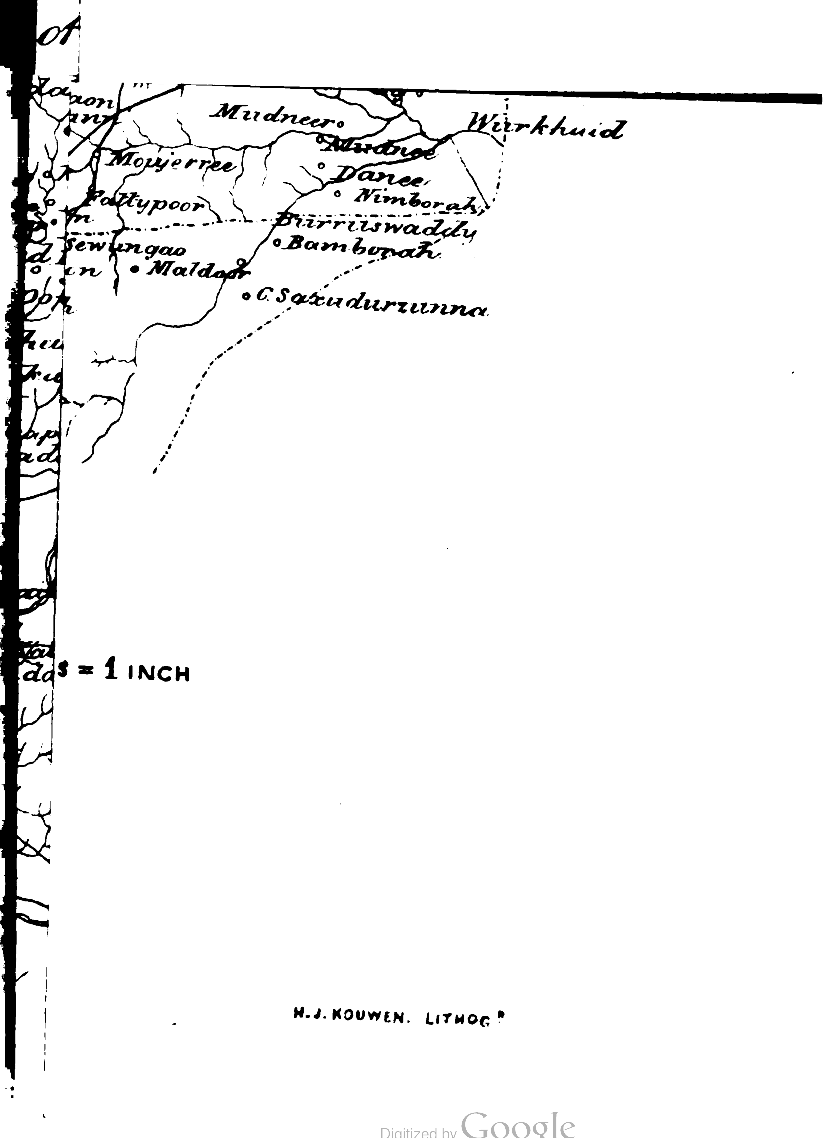
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removed as to leave the metal malleable. We can readily believe that Mr. Bessemer's process will expedite the manufacture of wrought iron; but extended experiments are required to shew that he can dispense with the mechanical methods at present in use. Especially important, too, is it that accurate chymical analysis should be resorted to, to shew the composition of this iron, and to prove that the new process will truly purge it of sulphur and phosphosus, as we understand Mr Bessemer to say it will; elements, the presence of one per cent. of which is fatal to the quality of the iron. It would be scarcely possible by written description merely to make the mechanical contrivances intelligible which Mr Bessemer describes in the specification of his patent. It will suffice to say that they consist of contrivances for effecting a rapid and complete action of air on the iron—to do, in short, more effectually that which is already done in the refinery furnace.

We cannot close our remarks without in justice informing our readers that there at least "Two Richmonds in the field." Since the announcement of Mr Bessemer's process Mr Martien, of New Jersey, in the United States of America, has pointed out a prior patent of his, the essential feature of which is the forcing of jets of air or steam through molten cast iron for the purpose of decarbonizing it. Other claimants of minor importance have likewise presented themselves. Into the discussion of the question of relative merit between these gentlemen we shall not enter. We may in a future number give such extracts from the specifications of their several patents as will enable our readers to judge for themselves. In the meantime, however, we believe it is our public duty to state that, although we hope and believe that Mr. Bessemer's experiments will result in a great improvement in the manufacture of wrought iron, nothing is more likely to check the realization of so important an object than the extravagant excitement which at present obtains. In the hope of allaying the fears which many entertain that something like a "revo-

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lution " in the iron manufacture is impending—a notion which may not only lead to unfortunate commercial results, but is sure to be followed by a corresponding disappointment and neglect—we assure our readers that in principle nothing new is proposed by Mr Bessemer. The refining of iron by air is the only method of refining that has ever been practised. Mr. Bessemer, however, proposes a more direct and rapid method of applying the air, which appears to be more successful than could have been anticipated. This, as we have several times already said, we believe will prove to be a great improvement, but at present much remains to be done before these experiments can expand into manufacturing processes. In the interim the iron manufacturer may safely proceed with his present operations, and, unless we are much mistaken, everything which he now possesses will be found of use when Mr Bessemer's process has attained its highest perfection; for we think the invention under discussion will result in facilitating the manufacture of iron, by adding a process, or substituting an improved apparatus for the refinery. That the puddling of iron will be rendered unnecessary we very much doubt. In settling the position of rival claimants to the new method, we should also bear in mind that they differ from one another only in the details of the process; they all effect their object, more or less directly, by air. Iron, we repeat, has never been purified by any other means; and through a long succession of ages, though we may trace a gradually improved method of realizing the object aimed at, the principle has never varied. The Egyptian smith, whose race was finished before antiquity began, made his iron by calling into operation the oxidizing agency of the air.

Hall's improvements in the manufacture of Gunpowder.

At present the charges of a powder mill are moistened with water at the commencement of the milling operation, which milling is continued for several hours, and as often as the

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charges become partially dry, they are again damped by sprinkling water over them by hand with a small watering pot while the mill is in motion, but the distribution of the water is not always uniform or limited precisely to the quantity required. Mr. E. Hall, of Dartford, has therefore introduced into this part of the gunpowder manufacture certain improvements, which consist in arranging apparatus by which the exact quantity of water can be sprinkled over the charges in a given time, and continued with little variation for an indefinite period, by which means the charges are better worked, the loss from dust is diminished, and less risk of acccident is attained.

To provide water for the apparatus, a small pump, with slow motion, is used to raise a supply to a cistern sufficiently elevated for the distribution of the water by means of small pipes to all the mills which are contiguous, each of the mills being provided with a smaller cistern fixed to the stone shafts, and revolving with them. Each of the shaft cisterns in the mills is provided with a float valve for admitting a regular supply of water to them, so that the head of water of the sprinkling pipes is maintained in each case at an uniform elevation, which facilitates the adjustment of the quantity of water to be expended on the charges. From the shaft cisterns the water is conducted through small pipes down to near the surface of the mill beds, where a perforated pipe attached to the stone shaft revolves and distributes the requisite quantity of water over the charges. To regulate with precision the quantity of water to be expended on the charges, a cock is provided with a small aperture, and also an index, so as to be capable of nice adjustment; and below this regulating cock a stop-cock is provided for shutting off the supply of water from the sprinkling pipes during the time the charges are taken off and others laid on the mill beds. A steam pipe from a boiler is conducted into the water of the shaft cisterns when it is required to be heated for the

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mill charges, and the steam supply is regulated by a cock, as required.*

Cochran's Improvements in casting Mortars and Cannon.

Mr. J. W. Cochran, of New York, whose rotating shot and shell were described and illustrated at p. 267 of our last volume†, has recently introduced into this country certain improvements in casting mortars, guns and other hollow articles, which improvements consist in so arranging the various parts of the mould in which the casting is made, that the rate in which the metal is allowed to cool, shall be under the perfect control and regulation of the founder. This is effected as follows: The inventor takes an ordinary mould, composed of suitable materials, which is to form the matrix cf thc casting, and encloses it in an outer casing containing a non-conducting material, such as anhydrous gypsum, whereby the escape of heat from the external surface of the mould is arrested. The core which is employed for the cavity or hollow of the casting is composed of the ordinary loam, with an admixture of gypsum, to harden it and prevent scaling, and in this also is inserted a metal core barrel without perforations, and roughened on the external surface to cause the loam to adhere to it. This core barrel is suspended from, or otherwise attached to the mould case, and leaves one or both ends open as convenience may suggest. For short castings the attachment will be sufficient at the top, and the lower end may therefore be closed or hermetically sealed, the core being kept in its place by two or three grains or stays, at or near the lower end. In the centre of the core barrel reaching nearly to the lower end is inserted a tube, which is connected with an elevated tank of water or with a forcing pump or other engine, and a stream of water is caused to flow down this tube and to rise up through the core barrel with a *velo-*

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* Mechanics' Magazine, 1st March 1856.

† No. 1676. Vol. lxiii.

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city proportioned to the desired rate of cooling. The difference of temperature between the water and the metal casting, causes the heat contained in the latter to pass through the core, where it is rapidly absorbed by the water, which, when so heated, may be carried away through suitable channels, the temperature of the water being kept under the evaporating point. Where the casting is of great length the core barrel may be continued through the bottom of the mould to obtain a more secure fixing, and being left open may be connected with a supply tube, conveying water upward, which may be discharged in any convenient manner. The same object may be partially accomplished, though less perfectly and efficiently, by passing a current of air through the core barrel instead of water.*

A new weighing instrument.

A new weighing instrument has just been invented by Professor Kaeppelin, and called by him the "hydrostat." It is based on the same principle as Nicholson's aërometer.

The "hydrostat" consists of a cylindrical case filled with air, hermetically closed on all sides, and entirely immersed in a vessel containing water, where it forms, as it were, a float. (In places in which the temperature is at freezing point, alcohol must be substituted for water.) Two plated steel wires are connected to the air case or float, and rise out of the water vertically. These wires are fixed to the extremities of a horizontal beam, having at its centre a rod, to which are suspended two dishes, placed one over the other. One of these dishes is for the weights which have been required to immerse the float; the other is intended to hold the substances to be weighed.

The instrument is made use of in the following manner; First, the fixed point at which the horizontal beam is stopped must be noted; then the substance to be weighed is placed on the proper dish, and weights removed from the other dish

* Mechanics' Magazine, 12th April 1856.

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till the instrument returns to the original point of immersion. The weights removed will indicate the weight of the substance weighed.

The precision of the instrument will depend on the thickness of the steel wires, as the water displaced by them regulates the last and smallest fractions of the course of the float. The nicety of the instrument arises from the absence of all friction except that from the contact of the water against the surface of the float. It is, therefore, especially applicable for weighing precious stones, &c.

Changes of temperature affect the volume of the float as well as the density of the water; the "hydrostat" must, therefore, always be brought back to the fixed point, whenever it has departed from it.

The instrument has been applied with success by Messrs. Haussmann, Jordan, Hirn and Co. of Colmar, for weighing cotton in the manufacture of table-cloths.

*Moniteur Industriel.**

Shells that explode by falling on water.

To the Editor of the Mechanics' Magazine.

Sir,—I this day fired a paper shell, fitted on the head of an arrow, from the pier head, near the Rosherville Hotel, into the river where the water was 12 feet deep, in presence of several persons attendants at the pier. I shot the arrow *vertically*, so as to ensure the most direct fall on its head. The percussion or frictional appliance used is the same that I attach to my rifle-shell when I wish it to explode against loose flowing canvas, also for inserting in the bottom of the round iron bar for striking on the head of my percussion cartridge for blasting the roots of large tress in clearing forest land. Specimens of this appliance are to be seen in the museum of the United Service Institution, the Polytechnic, Regent Street, the Crystal Palace, and the Institution of

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* Mechanics' Magazine, 7th June 1856.

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Civil Engineers. About 12 years ago, when I successfully tested my spherical concussion shells, fired from the 8 in. and 10 in. bore guns from on board the *Excellent* gunnery ship, at Portsmouth, some of the shells exploded on striking the water. This resulted from the rivets in the fuzes having been too delicately set in their sockets, snd was considered by the members of the committee to be a defect in the efficiency of the shell; but this facility of causing spherical shells to explode on striking the water will, in many cases, be of great utility, particularly for shells charged with Mr. Wentworth Scott's liquid fire, because a shell so exploding within fify yards of an enemy's ship, would cause the liquid to fall like a shower of rain on the devoted ship. My next experiments will be to prove that I can cause percussion rifle shells to explode on striking the water, when fired from my three-grove four-pounder rifle cannon, which was formed perfect for use in the casting, without further preparation, with the exception of drilling the vent.*

I am, Sir, Yours, &c.,
J. NORTON.

Rosherville Hotel, May 31st, 1856.

Improvements in tanning skins and hides.

Avery important improvement in the process by which skins and hides are tanned, has recently been introduced. It is the invention of Mr. Funcke, a practical tanner and currier, of Herdecke, Westphalia, who has obtained a patent for it in this country.

It consists in expediting the introduction of tannic acid into the interior of skins and hides, by counteracting a too rapid action of the tannic acid upon the surface only of the skins and hides, which thereby would be hardened. The mode of operation adopted is as follows:—1. The unhaired skins or hides are passed through water in which soda of commerce has been dissolved, and are then hung up and allowed to become nearly dry before the actual tanning process is

* Mechanics' Magazine 28th June 1856.

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proceeded with. 2. Diluted vegetable acids are added to extracts of bark or other vegetable substances containing tannic acid, and the skins or hides are subjected to the action of the combined liquids, by being steeped therein, by which the pores of the skins and hides are opened and extended, at the same time as they are exposed to the action of the tannic acid. 3. The skins and hides are again subjected to the action of a liquid similar to the last, by steeping them therein; but in this case vegetable acid, somewhat stronger than the former, is taken, and its action is softened by the addition of a solution of sugar. 4. While the skins and hides are subjected to well known mechanical lifting and falling action, they are subjected to the action of a liquid containing tannic acid, until the leather is finished; but as the tanning liquor in this process, in order to act with expedition, is of such strength as to give to the leather a colour too deep for most purposes, the colour is reduced when required by some sulphuric acid, salt being added, in this last stage of the process, to the tanning liquid in which the skins and hides are worked.*

Novel method of mounting Guns in Gun boats, &c.

M. Deloigne, of Paris, has brought forward an invention, the object of which is to avoid the injurious effects to ships, gun boats, and rafts, arising from the recoil of heavy mortars or pieces of ordnance fired at a considerable angle of inclination, and the invention consists in forming a well through the boat or raft, in which well the piece of ordnance is to be mounted so that the water shall receive the recoil. In this well a water tight cylinder, somewhat smaller in diameter than the well, is placed. The cylinder is supported in the well, being attached to the boat or raft by vulcanized India rubber or other springs, and is free to move up and down between guides in the well. Its bottom is formed by the breech plate of the gun or mortar, which is made as is well understood. The bottom of the cylinder is by preference

* Mechanics' Magazine 4th October, 1856.

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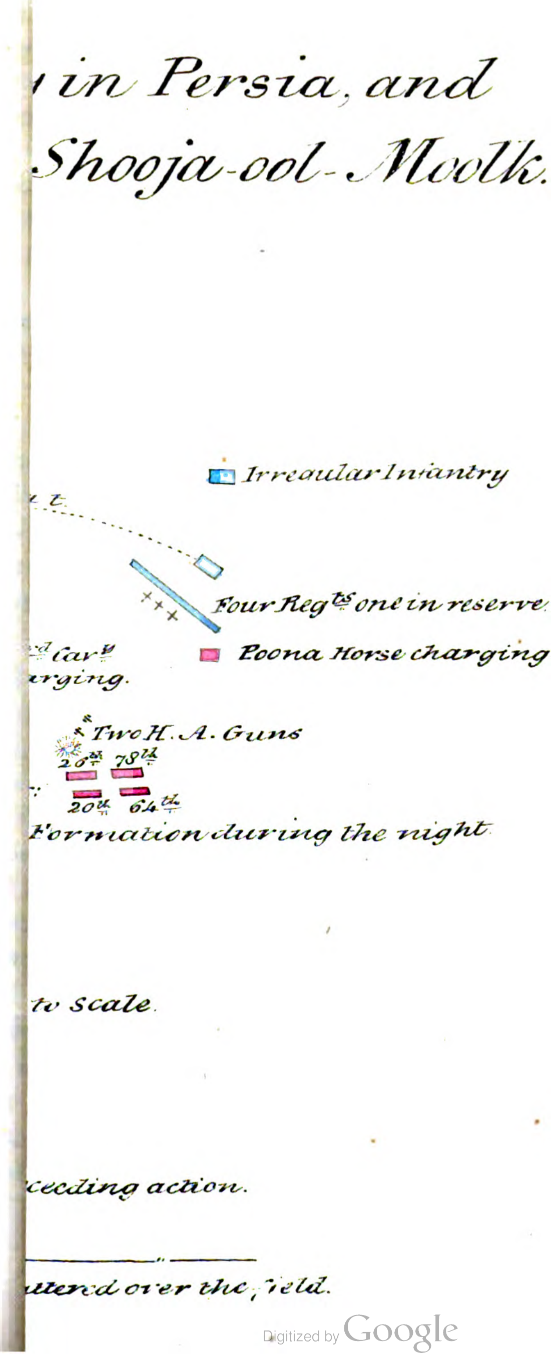

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made to be below the line of floatation, so as to be constantly surrounded by water inside the well. Or instead of causing the breech to act direct, and making a well in the boat, a strong rod running through the boat supporting the gun at its upper end, and having a suitable place at its lower end in the water, with suitable spring to keep the upper end tightly against the breech of the mortar, may be made to serve as intermediate between the gun and water; or other analogous means may be used.*

Affair between the British Army in Persia, and the Persian Army commanded by Shooja-ool-Moolk—by a Correspondent.

My dear,————

You will like to have some account of the affair which took place here on the 8th. I dont suppose any Troop in India ever killed so many men in one day as the 3d did at Khushab—I should howevêr like to see our opponents show a little better fight. Their guns did well and fired grape and round shot steadily, but they were badly supplied with ammunition.

On the 3d Instant, the whole force at Bushire, (deducting for a small Garrison left behind,) marched to attack the enemy; who, numbering from 6000 to 7000, with 14 guns, had assembled at the Town of Borazgoon, 40 miles distant. On arriving there, we found the camp deserted, and a quantity of provisions and ammunition abandoned. The enemy only retired 12 miles to Dalikee. I think we should have followed them, as they had got to a pass, up which their guns could not go; and Sir J. Outram gave the orders to be ready, but changed his mind two hours before starting.—The Commissariat Officer made difficulties, I believe.—We commenced leaving Borazgoon for Bushire at half past 8 of the night of the 7th; the rear guard blowing up the captured ammunition.—Meantime, the Persian Commander-in-Chief had changed his mind about fighting, and marched from

* Mechanics' Magazine, 11th October 1856.

Dalikee at 5 P. M., the same evening, to attack us without knowing we were about to leave Borazgoon.—The explosion occurred when he was only a mile from Borazgoon, and rather startled him; but some towns-people soon told him how matters stood.—He must have been in a warlike humour, for he determined to follow us up, and by taking a short cut, overtook us at 1 A. M. next morning.—The first thing he did, was to surround us with small parties of Cavalry, howling and firing matchlocks. At first we were in some confusion, as this attack was utterly unexpected.—Never was there a greater instance of the validity of the maxim, to be always ready for an attack!—The General got a tumble, which stunned him; the night was very dark and rainy, and for an hour, I should have been sorry to see 500 horse dash at us, or even 500 Infantry well formed.—By half past two, everything was reduced to perfect order; chiefly through the exertions of Colonel ——— Chief of the Staff,* a steady experienced Officer much liked by every body. At 3 o'clock, to our astonishment, the enemy opened four guns, one of which was an 18 Pdr.! They got our range very well, but only fired round shot, and, as you know, round shot when fired with a high elevation, is little more injurious than rifle balls; although better than anything, to sweep through columns at 700 or 800 yards.—One Officer of the 64th lost his leg, and several men and camp followers were killed and wounded.—We could only bide our time till morning; the night was so dark, that nothing offensive could be tried.—The Cavalry were drawn up, all ready to seize the guns at daylight; though we never expected they would stay so long.—When day did break, I could hardly believe my eyes when I saw two masses of Infantry, not a mile distant; Cavalry in all directions and several guns!—our Artillery (3d and 5th Light Field Batteries and 3d Troop H. A.) went to the front immediately, and the Troops, who had hitherto been in an oblong square, took a position. (as in sketch, Plate 25,)—The enemy deployed one mass into line which was broken by the Artillery fire and

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Poona horse charging. The other mass was terribly pommelled by the F. Batteries with spherical case. The 3d Cavalry, a splendid Corps, then charged :—The Persians received them in square, and were much cut up.—After this, they made no further organised attempt to resist ; and when our Cavalry, which is only 400 strong, had reformed, and got clear of their wounded men and horses, (for they had quite got dispersed, having no support near) a pursuit commenced.—The Cavalry and Horse Artillery followed for 5 miles; every now and then, stopping to give the guns a play on the dense masses.—The 3d Cavalry, who had lost their Colonel before at Bushire, were quite mad; I counted 40 killed by them in one small space!—The whole line was strewed with pouch-belts and muskets, thrown away as impeding flight.—The fault of this action was, that our Infantry was kept too much back ; and the Cavalry sent on too soon ; the latter, I believe, charged without orders, or at least some Staff-man told them to do so without proper authority.————would insist on the Infantry being halted just behind the guns; and when urged to push on, said they should'nt go before the guns,—as if the guns could'nt go on too !—He saw the mistake I think after.

The Infantry did not fire a shot, except at stray horsemen on the left, trying to get at the baggage.

I am in a hurry so excuse this scrawl.

They say some Madras Horse Artillery Troops are coming up.

We had frightful weather during our march, rain and cold—a move will probably take place from here in six weeks meantime the Troops are going to take Mohumrah which will not be a difficult job.

Yours &c.

Bushire February 15th, 1857.

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The new American Steam Ships of War.

The visit of the large American Steam frigate *Merrimac* to Southampton having occasioned considerable interest, we think it may now be a proper time to lay before our readers such information as we have from time to time obtained respecting her, and the *Wabash*, the *Minnesota*, the *Roanoke*, and the *Colorada*—four ships of much the same size and power as the *Merrimac*. In order to render the information which follows perfectly reliable— in so far, at least, as the *Merrimac* is concerned—we have visited that vessel, and verified by personal observation the facts hereafter stated. In making this verification we were favoured with the utmost courtesy and co-operation on the part of the officers of the ship, and particularly of first Lieutenant G. W. Harrison, who was in command of her at the time of our visit, and to whose kindness we are much indebted.

The principal dimensions of the five frigates above enumerated are so nearly alike that they may, for all ordinary purposes, be considered the same, and may be taken as follows ;—*

	feet.	ins.
Length on keel	250	0
Length on load water line	260	0
Length over all	300	0
Breadth extreme	51	4
Breadth moulded	50	2
Depth of hold (to gun deck)	26	4
Draught of water, forward	23	6
Draught of water, aft	24	0

As our examination of the *Merrimac* was made for the purpose of estimating her merits as a ship of war, we must add to the above the following details which are of importance in such a ship. When the vessel is at her load line, the heights of the gun deck ports above the water are amid-

* Almost the only difference between the dimensions of these five frigates is a slight one in their lengths. But this is a difference of about five feet or six feet only at most. The *Wabash* is said to be 5 feet 8 inches longer than the *Merrimac*; but even this is true only when the length is measured at the load line.

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ships 9 feet, and forward and aft 12 feet, or thereabouts. The height from her gun deck to the lower sides of her spar deck beams is 6 feet. The height of her bulwarks is such that, when the hammocks are stowed they reach 8 feet 8 inches above the upper deck. Her gun deck ports are 3 feet 8 inches long, and nearly 8 feet 6 inches apart. Her load displacement is estimated at 4000 tons; but this we could not, of course, test.

The *Merrimac* was designed by Mr. Lenthall, who is at the head of the Bureau at Washington, and was built by Mr. Delano, the master shipwright of the Navy Yard at Boston, (or the officer who corresponds to a master shipwright of our own dockyards.) Her frame is of live oak, crossed on the inside with two sets of diagonal iron plates which are inclined in opposite directions. She is also strengthened by similar plates on the outside at bow and stern. Her plank is also of oak, and, like our own ships of war, she is copper fastened up to a few feet above the load water line. Her decks are of fir. On a careful inspection, she seems to have been built with very great skill and care, and is a very tight strong ship. The large wooden knees (common in American ships because more approved of, and more readily obtained than iron) to some extent interfere with the beauty of her appearance in board. But she is a very roomy and handsome ship, and the appearance of her main deck is unsurpassed.

With all her sails set, she spreads 56,629 square feet of canvass. Her engines are auxiliary only. Her rig is in all respects like that of the largest American sailing frigates, but from her great length she seems capable of carrying masts, spars, and sails even larger than those she has. The mode in which the mainmast steps is worthy of attention. The shaft of the propeller coming immediately beneath it, (since the engines are before the mainmast,) a step is formed to receive it above the shaft. This step consists of a large thwart ship beam of live oak, supported near the middle by two 12-inch solid iron columns which rest upon suitable keelsons. This

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arrangement is perhaps as good as any other, although the strength attending it must certainly be much less than that in which the mast steps in a wooden step supported immediately by the keelsons themselves, as in the case where no screw shaft interferes. The modes adopted in our own navy are various. In some cases tall iron forked steps, which stride across the shaft are employed, and in others the heel of the mast itself is enlarged, and the shaft allowed to pass through it, the lower piece of the mast being separable from the upper, and connected with it by clasp jointed hoops.

The *Merrimac* is pierced for 60 guns, but if she were actually to carry that number they would have to be of a lighter character than those now on board of her. Her present armament is as follows:—On her upper deck there are two large pivot guns, each weighing nearly 5½ tons, and of *10* inches bore, and fourteen 8-inch guns, each weighing rather more than *3* tons; on her gun deck there are twenty four 9-inch guns, each weighing nearly 4½ tons. The whole of these guns, forty in all, though strong enough to discharge solid shot, if desired, are primarily intended to be served with hollow shot, or with shell,—for it is now a practice with the Americans to supply their navy with a quantity of empty hollow shot, which may be either plugged and used as such, or charged, fitted with fuzes, and used as shells. We must not, however, omit to mention that she might carry a few additional 9-inch guns on the main deck with perfect convenience. Her gun carriages on the main deck are similar to those used in the French navy. They have, however, but two wheels or trucks each, at the ship's side end of the carriage. To facilitate the running out of the gun the rear end of the carriage is raised by a handspike fitted with a roller at the end, on which roller the carriage runs out. At the upper side of this handspike roller is a pin or stud which takes into one or other of a series of recesses formed in a plate on the under side of the rear end of the carriage. The carriage slides of the large pivot guns differ from our own

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chiefly in the fact that they are furnished at each end with wheels or trucks (which run on the metal circular bearing plates on the deck) mounted on eccentric axles. These axles are turned by a spanner, so as either to take the weight of the slide and allow it to be run round upon them, or to be raised clear of the bottom of the slide, and allow it to rest immediately upon the deck plates. The carriages which run upon the slides have their rear trucks mounted upon similar eccentric axles. The friction of the carriage upon the slide when the piece is to be discharged (and when the trucks are clear of the slide) is sometimes increased by nipping the two together with screws.

The whole of the 9 inch guns, or main deck guns, as well as the two 10-inch pivot guns, are formed upon Commander Dahlgren's system, which consists in giving to the gun, at each point of its length, a thickness proportioned to the direct pressure of the powder in the chase at that point, supposing the gun to be fired with an ordinary service charge. In order to carry out that principle, Commander (at the time Lieutenant) Dahlgren took an ordinary Paixhan gun, and had bored in it a number of holes, each of the size of a musket ball, extending from the outside of the gun through into the chase. These holes were perpendicular to the axis of the gun. A musket ball was then placed in the first hole (the remainder of the holes being plugged for the time), the gun fired with a service charge, and the initial velocity communicated to the musket ball measured by a ballistic pendulum. This was repeated with each hole successively, and lines representing the initial velocities thus obtained were taken as the ordinates of a curve (of which the distances apart of the holes represented the abscissæ), and this curve gave the contour of the exterior of the gun. The Dahlgren guns are of greatly reduced thickness along the chase, and suddenly increase their thickness near the breech, where the great bulk of the metal of the gun is collected. Before the adoption of them in their navy, the American Government

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had them severely tested, with highly satisfactory results. Without doubt, the principle of Commander Dahlgren is correct, so far as it goes. There are also collateral advantages connected with the adoption of it in naval ordnance, one of which is that the centre of gravity of each side battery is, owing to the form of the guns, thereby brought nearer to the middle of the ship, which must tend to make her roll less heavily than otherwise. Each gun is furnished with two lock lugs, or lugs for the gun-lock—one for use, and one to supply its place if it should be knocked away.

There are a few other novel features in connection with the guns of the *Merrimac*. One is that her guns are fitted with elevating screws, which supply the place of the *Coin*, &c, in our service. This arrangement tends greatly to facilitate the sighting, and is certainly an improvement, provided that it is not attended with any defect in strength, and we were assured that none had been observed during considerable practice. Another new feature is the employment of bristles, instead of sheepskin, in all the sponges and rammers for the guns; and a further one is the employment, for boat guns, of light and elegant wrought iron carriages, of which she has three, one for a 9-pounder, a second for a 12-pounder, and a third for a 24-pounder.

The greatest speed ever attained by the *Merrimac* under steam alone was seven knots per hour, and this was made under very favourable circumstances. Her average steaming speed is much less than this.*

Extract from Notes of a visit to the United States' Frigate "Merrimac" by a Naval Officer.

There is a great deal of "bright-work" about her—large brass awning or hood stanchions over every hatchway; all these were highly polished, together with the brass guns for the boats, elevating screws of guns, &c.

The guns were nicely polished, and generally appeared

* Mechanic's Magazine 11th October 1856.

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well kept; they are fitted with elevating-screws, the fitness of which for long guns is questionable. In short pieces, such as carronades, where the circle described by the breech in elevating or depressing is not much, the slow effect of the screw is more sensibly felt than in the larger circle described by the long gun; hence the pointing of the gun must take longer than with the handspike and quoin. The carriages are on the French plan, without trucks on the after part, and worked by roller handspikes. There is no question but that on this plan the shock of recoil is more severely felt than when the gun recedes more easily under its force. The sponges are made of brush bristles instead of wool, as in our ships. This is a great improvement. The locks of the guns are on the hammer principle, with back spring action, but not so simple as those used in the British Navy. The breechings are fitted with solid or shackle-eye thimbles for drop bolts, instead of thimbled-eye thimbles, as we use. It makes the breeching stand up stiffer to its work. The boats guns are all of brass, and, for land service, are mounted on three-wheeled iron hand carriages. They did not appear more siutable for service mounted this way than if on regular land carriages. The muskets are all rifled on the minié principle; we found, however, the locks very stiff and hard, and not suitable for precise firing. The best of shots could not ensure a good shot with one of them. The pistols are upon the common percussion plan. Upon enquiry, it appeared that there are not any revolvers amongst the public armament. The cutlasses appeared short. The guns are more swelled at the breech than our ordnance. The armament of the main deck battery consisted of 9-inch guns; the upper deck, 8-inch, and two 10-inch pivot guns, one on the forecastle, and one on the quarter deck (40 in all); the bulwarks being made to fall down to work these guns. We could not see the arrangement of the magazines and shell-rooms; but it struck us that the light-room of the fore magazine was insecure, a very light door only separating it from the gunners store room.

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The main deck is low, and disappointed us; from the capacity of the ship, a finer gun deck might have been expected. The employment of wooden knees, instead of iron, also gives a clumsy appearance to the deck; this old fashioned mode of construction is remarkable. A very noticeable thing was the abundance of large hatchways and ladders, a very good thing in a ship of war.*

Armstrong's Improved Ordnance.

Mr. W. G. Armstrong, of the Elswick Engine Works, Newcastle-upon-Tyne, whose engineering talents are well known, in the latter part of 1854 submitted to the Minister at War a proposal for a gun which he anticipated would possess great superiority over the common forms of light Artillery, and undertook to construct a field-piece in conformity with the plan suggested. This gun has, during nearly two years, been the subject of numerous experiments, partly at Shoeburyness, but principally under Mr. Armstrong's own direction in the North. The following account is prepared from the published statements of the inventor.

The gun is composed internally of steel and externally of iron, applied in a twisted or spiral form, as in a musket or fowling-piece. The bore is nearly 2 inches in diameter and is rifled. The projectile is a pointed cylinder 6½ inches long, weighing 5 lbs., of cast iron, coated with lead, and is fired with a charge of 10 oz. of powder; it has a small cavity in the centre, and may be used either as a shot or a shell. When applied as a shell the cavity is filled with powder, and a detonating fuze is inserted in front, so as to fire the powder in the centre on striking an object. When used as a shot the powder is omitted, and an iron point, which favours penetration, is substituted for the fuze. The gun loads at the breech, not only to obviate the sponging and loading from the front, but also to allow the projectile to be larger in diame-

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* Mechanic's Magazine 8th November 1856.

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ter than would enter at the muzzle, and thus to insure its taking the groove and completely filling the bore. The piece weighs 5 cwt., and is mounted upon a carriage which resembles that of an ordinary 6-pounder field gun, but which embraces a pivot frame and recoil slide. A screw is applied, not only for elevating and depressing the gun, but also for moving it horizontally, by which means great delicacy of aim is effected. The recoil slide inclines upward, which enables the gun after running back to recover its position by gravity; its use is to relieve the pivot-frame and adjusting screws from injurious concussion.

The following are some particulars of experiments recently made with this gun on the coast of Northumberland, near the village of Whitley under the official inspection of Colonel Wilmot.

Fourteen shots were first fired 1,500 yards at a timber butt, 5 feet wide and 7½ feet high. Six were expended in finding the proper elevation, but every succeeding shot hit the object without previous graze. The final elevation of the gun was 4 deg. 26 min., and the mean lateral distance of the shot marks from a vertical line through the centre of the butt was only 11½ inches.

"The ordinary 6-pounder field-piece," says Mr. Armstrong, "which in point of weight forms the nearest approach to the present gun, is perfectly useless at a distance of 1,500 yards, and is very uncertain even at 1,000 yards. It is only, therefore, with heavy Artillery that a comparison can be drawn, and it will be sufficient to state that in tabulating the practice made with such ordnance the deflections are invariably recorded in yards, whereas with this rifled gun they can only be properly given in inches."

With respect to penetration, the following particulars are remarkable. The butt was 3 feet thick, composed of six layers of rock elm bolted together, so as to form a solid block

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One shot passed entirely through; another struck near the edge and glanced; and the remaining six passed nearly through.

Shell firing was next tried at 1,500 yards, at the same elevation and with the same charge as before. Two targets were erected, one behind the other (so as to appear as one when viewed from the gun) with a space of 30 feet between them. The front target was to exhibit the perforations of the shells before bursting, and the back one the effect of the fragments resulting from explosion.

Twenty-two shells were fired at the front target, and of these only one missed the object of aim; seventeen hit the first target direct, and burst behind it, the fragments penetrating the second; three grazed and burst immediately in front of the first target, and perforated both with the pieces; one hit the bottom of the first target and exploded in the ground; and the remaining one missed entirely. "A strong side wind was blowing at the time," says Mr. Armstrong, "and accounted for the deviation of this single shell."

Four shells and three shot were then fired at an elevation of 6 degs., from a distance of 2,000, or, more accurately, 1,964 yards. All these struck within the breadth of the target, but, the elevation being scarcely sufficient, fell a little short.

The results of this shell firing were as follows:—The front target contained 51 holes, and the back one 164, while the ground between and adjacent to the targets exhibited about 70 perforations by fragments of shells.

On previous occasions the gun had been tried up to 3,000 yards, which was reached with an elevation of 11 degs., and the usual charge of 10 oz. of powder, of one-eighth the weight of the projectile. By augmenting the charge the range is increased, but the accuracy is impaired. Mr Armstrong observes that "the ranges obtained with this charge (10 oz.) bear a favorable comparison with those of the heaviest round shot guns fired with a much larger proportion of powder."

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It is a curious fact, and one which greatly increases the efficiency of the shells, that owing to the bursting charge requiring a short space of time to mature its ignition after the firing of the fuze by impact, the shell is enabled to travel four or five feet after striking an object before disruption takes place. Hence, it acts as a shot before it bursts as a shell. If, therefore, it were fired against a Ship, it would first penetrate the side, and then, bursting, traverse the deck in fragments; or if directed against troops, it would pierce the front line as a bullet, and operate like grape shot beyond. The shells are said to explode with certainty whether the substance struck be hard or soft, and even burst on the surface of water, provided the elevation be not too great.

In the course of the long series of experiments made with this gun, it has been fired nearly 1,300 times without sustaining any permanent injury either in the breech loading arrangement or otherwise. The only parts exposed to wear are separable from the gun, and can with great facility be renewed.*

A day with the Prussian Artillery.

To the Editor of the United Service Magazine.

Dear Mr. Editor,—It was the good fortune of your occasional contributor to pass one day, towards the latter end of July last, with the Prussian Artillery at their practice-ground at Wahn, a village some ten or twelve miles from Deutz and Cologne. I purpose giving you an account of what I there saw and heard, and hope that my narrative may prove even one half as interesting to such of your readers as care to know what is done in the foreign military world as the reality was to me.

The practice ground itself is an open heath, with a fine range, both as to depth and width. The soil is sandy, but covered with short grass or heather, and affords, on that por-

* Mechanic's Magazine, 10th January 1857.

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tion of it reserved for drill, as fine a piece of galloping ground as could be desired. It is the property of the government, having been purchased, with the idea of thus using it, upwards of thirty years ago. On the ground are some half-dozen wooden huts, of a temporary character, serving the various purposes of orderly room (inscribed "PAROLE"), laboratory, canteens for officers and men, and store and powder magazines. The park has nothing more to mark its extent than a rough paling, and the requisite number of painted boards, indicating the place of each battery. The *matériel* and *personnel* belonged to the 8th Regiment of Artillery, under the command of Colonel Von Podevils. The regiment, being on the peace establishment, was thus composed :—

8th Regiment.	1	1st Foot Artillery Div..	2-12 pr. batts. of 4-12 prs. each.*
			2-6 pr. „ of 3-6 prs. and 1-7 pr. how. each.
	2	2d Foot Artillery Div...	1-12 pr. „ of 4-12 prs.
			1 how. „ of 4-7 prs.
			2-6 pr. „ of 3-6 prs. and 1-7 pr. how. each.
	3	Garrison Siege Division, 4 companies of garrison or siege artillery.	
	4	Horse Artillery Div...3 batts. of 3-6 prs. 1-7 pr. howitzer each.	
	4 divs.	11 batts. and 3 comps.	33 guns and 11 hows. or 44 pieces.

In addition to the above, the regiment has one artificer's company, now engaged in construction, with two other companies of different regiments, at the arsenal at Deutz (Cologne). The *personnel* consisted of 87 officers of all grades, 1,478 men, and 605 horses, inclusive of officers' chargers. All this *personnel* was cantoned in a circle of a six mile's radius round Wahn. The morning parade assembled daily at 7 A.M., and consequently some of the men must have left their billets at 5 A. M. It appeared strange at first sight that the

* The following are the dimensions, and weights of the Prussian field guns :—

Piece.	Length in			Diameter of		Charge.	Weight.		
	Calibres.	Ft.	in.	Shot or Shell.	Bores.				
				in.	in.	lbs.	cwt.	qrs.	lbs.
6 pr. brass gun.....	18	6	6·6	3·6	3·7	2·6	9	3	7
7 pr. „ howitzer	6—7	..		5·66	5·83	1·95 / 0·49	10	0	24
12 pdr. „ gun.....	18	7	0·6	4·42	4·67	4·55	20	2	0

government did not construct barracks, or at least permit the men to hut themselves on the ground. On enquiry, however, it seems that it is considered a better system to accustom the officers and men to being cantoned in the neighbouring villages, thus giving the young soldiers a good lesson in that kind of existence; and further, that the march to and from the practice ground inures the men to fatiuge—a fact which will be better understood when it is stated that they do not leave the practice ground any day till between twelve and one o'clock. They have thus 6 miles to march to the ground, from five to five and a half hour's drill, with an interruption of a quarter of an hour's rest, and six miles to return, their horses to groom, and their equipments to clean. It will be thus seen that the work is no child's play.

The annual practice lasts thirty-five days, and most assuredly the best use is made of that period of time. Before the troops leave the various garrisons to proceed to the practice cantonments, the Colonel of the regiment publishes a lithographed pamphlet of upwards of one hundred pages, containing a programme of the practice, &c. Each officer is furnished with a copy, and others are distributed for the use of the various batteries and companies; each officer and man must thus be fully aware long beforehand of every arrangement, even to the most trifling detail, regarding each day's practice. I shall now run through this pamphlet, and thus be better enabled to give you a more accurate idea of the method of carrying on the practice than by pursuing a less formal course.

The index to the pamphlet is dived into nineteen heads:—

1. *Distances at which the practice is to be carried on.*

With the field artillery there are ten distances, varying between, 1,400 paces (1,111 yards) and 300 paces (250 yards.) With siege or garrison artillery there are six distances, between 900 paces (750 yards) and 150 paces (125 yards).

2. *Table of charges and elevations for ricochet firing.*

3. *Table of the length of fuse.*

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These tables contain the requisite practical data.

4. *Information regarding the practice of the field artillery.*

5. *Information regarding the practice of the garrison or siege artillery.*

Here we have detailed the number of rounds to be fired from each piece, as well as an indication of the number of rounds of each nature to be fired for the government prizes for good practice—the number of rounds to be fired at the commanding officer's review—and the number at the inspection. The *rèsumè* is as follows: Field guns, 2,384 round shot, 739 common shells, 120 shrapnells, and 33 red-hot shot—this includes 351 rounds, to be fired at 1,100 paces (916 yards), for prizes—total, 3,276 rounds. From the siege or garrison artillery 1,673 rounds, inclusive of 132 prize rounds. Grand total of rounds, 4,949 or in round numbers three rounds per man.

6. *Data derived from practice as to the probability of a hit, for all pieces and distances, for the year* 1856.

This is a table of the probability of striking a target of certain known dimensions, taken from a size of the objects which artillery is likely to fire at in the field. For instance, the round shot and grape practice takes place at a target measuring one hundred feet long and 6 feet high, this being the average front of a column of attack of infantry formed in double column of subdivisions. Such tables, as far as I am aware, have never been drawn up in the British service. They are of obvious use, and tend to a certain extent to make artillery an exact science, as far as the numerous elements of its intricate problems admit. They have long been in existence in the French and other services. By them a fair judgment can be passed upon any given day's practice, and the comparative destructive powers of various pieces and projectiles may be thereby fairly estimated.

7. *Regulations for telegraphing.*

To any one who has had experience of artillery practice,

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an invention which shall lessen the loss of time occasioned by the communication of the result of each round from the target to the battery, when made by written report, or the uncertainty in making such communication in boisterous weather by sound, the following simple telegraphic system will be welcome.

General Directions.

1. The firing must not commence until the lieutenant-fireworker on range duty shall have lowered his flag and set up the telegraphic frames. The firing must cease immediately upon the latter being lowered and the flag hoisted. The flag at the battery is invariably to be in the hands of a bugler or trumpeter, who, on seeing the flag at the butt hoisted, must sound "cease firing," without waiting for further orders.

2. No piece is to be fired until the effect of the previous round is telegraphed. The pause which is to be made between the rounds in instruction practice is therefore regulated simply by the telegraph.

3. It is only during instruction practice that the telegraph is to be used. During proof practice it is not to be employed, and in this case the pause between the rounds is to be so regulated as to admit of an observation being made from the batteries.

4. During canister shot practice the telegraph is not employed, but each battery or company must take an account of its own practice. To enable them to do so, "cease firing" will be sounded as soon as the regulated number of rounds have been fired. A mounted orderly must then be sent to the lieutenant fire-worker on range duty, who will deliver to him a report of the result of the practice.

Telegraphing.

In order to ascertain the effect of each round, so as to enable the men in battery to correct, if necessary, the eleva-

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tion and direction of the pieces, and to convey the ne information, without loss of time, to the battery, it the duty of the lieutenant-fire-worker to make his o tions of the practice, and to communicate them by me two square frames, attached to staves, one of which is c with white linen, and the other with red. The latter ever, to make the distinction the more marked between has a diagonal white cross. (Fig. 1, Plate 26.)

Before the commencement of the practice, the tele signals stand upright, about 5 paces apart, in the imme neighbourhood of the butt, the white signal being next butt. (Fig. 2.)

The following is the telegraphic system :—

I.—When the object fired at is vertical.—

Practice with field pieces, exclusive of that with can shot or shrapnell, when used for dismounting guns bel parapets.*

(*a*) A first graze beyond the mark is to be indicated the inclination of one or both frames *outwards.* If the gr is 50 paces too far, one frame is to be so inclined (Fig. if 100 paces, both are to be inclined outwards (Fig. 4); 200 paces, the signal (Fig. 4) is to be made twice; 250 paces, it is to be made two and a-half times, or sign Fig. 4 is to be made twice, and signal Fig. 3 once.

(b.) A first graze short of the mark is to be indicated b the inclination of one or both signal frames *inwards.* If th graze is 50 paces too short, one frame is to be so inclined (Fig. 5); if 100 paces, both are to be inclined inwards (Fig. 6); if 200 paces, twice signal Fig. 6; if 250 paces, two and a half times, or twice Fig. 6 and once Fig. 5.

(c.) A direct line (hit without grazing) is to be indicated by lowering the *red* frame forwards.

* The object fired at with round and canister shot is a target 100 Prussian feet long by 6 feet high, being the average front of an infantry column formed for attack in double column of subdivisions from the centre.

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Plate. 26.

Fig: 4.

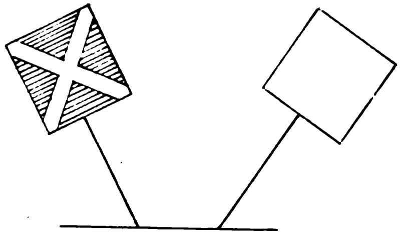
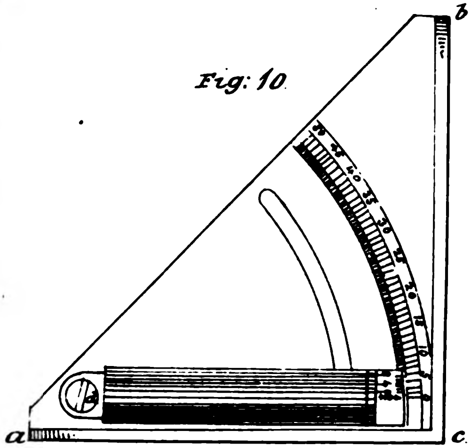


Fig: 10.



J.B.

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Remark.—Each shot which strikes the butt (not the target) without grazing is to be telegraphed as 50 or 100 paces over, according as it strikes, just above the target, or towards the top of the butt. In firing canister shot from embrasures the telegraph is not to be used, but a report is to be sent.

II.—When the object fired at is horizontal.—

*The redoubt, parallelogram, terreplein, covered way or butt battery.**

(a.) The *white* frame being lowered forwards indicates that the shell has fallen in the lesser square or parallelogram. In shelling the terreplein, covered way, or butt-battery, it indicates a hit in general terms.

(*b.*) The *red* frame being lowered forwards indicates that the shell has fallen in the larger square or parallelogram.

(*c.*) The telegraphing for shells short or over is the same as that laid down in Sec. I., paragraphs *a* and *b*.

(*d.*) Both frames being inclined to the same side, right or left, as seen from the battery, indicates that the distance is good, but the direction is faulty towards that side.

(*e.*) If a shell falls short or over, and is at the same time too much to the right or left, the distance is first telegraphed, and the direction subsequently.

Remark.—The two cases, as stated in paragraphs *d* and *e*, occur similarly in practice under Sec. I.

(*f.*) The points from whence the ranges, short or over, and deflections, right or left, are to be measured from, are—

* In firing common shells from howitzers, the objects aimed at are as follows: two concentric squares, having sides of 50 and 75 paces each, two sides of each square being parallel and two perpendicular to the line of fire. With mortars, on the other hand, the objects are two right-angled parallelograms, one within the other, having the longer sides of 100 and 50 paces respectively parallel to the line of fire. the other sides or breadths being 50 and 25 paces respectively. The other objects, such as those above named, are works of fortification of the usual dimensions.

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(*a.*) As regards the redoubt and the rectangles, from the staff surmounted by a triangle (pyramid.)

(*β.*) As regards the butt-battery,* from its crest.

(*γ.*) As regards the terreplein and covered way, the crest of the covering breastwork.

III.—When firing en ricochet from howitzers, it is generally necessary to telegraph twice for each round, so as to be able to regulate the charge and elevation, in order to leave the shell lying at a short distance behind the target. This lengthens the pause between each round.

A.—First Signal.

(*a.*) The *white* frame lowered forwards indicates that the target has been hit.

(*β.*) The *red* frame lowered forwards indicates that the shell has fallen within the square.†

(*γ.*) Both frames being inclined to the same side, whether right or left, indicates that the shell has passed to the one side or the other.

B.—Second Signal.

(*a.*) The errors in length of range are telegraphed as laid down in Sec. I, paragraphs *a* and *b.*

(*β.*) Both frames being lowered forwards indicates that the shell has struck the ground, and has embedded itself before reaching the butt, or that it has fallen short in consequence of some particularly disadvantageous grazes.

In the following instances in this practice it will only be necessary to telegraph once :—

(*a.*) When the shell goes over the butt.

---

* The butt is an embankment of earth, on the top of which is built a battery, thus ingeniously representing the rampart of a fortress surmounted by its parapet, pierced for guns.

† In this species of fire, the object fired at is a target 40 paces long by 6 feet high, standing in the middle of a square of 50 paces side,

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(β.) When the shell falls and remains lying in the immediate vicinity of the butt, *i.e.*, within the square of 50 paces.

(γ.) When the shell does not reach the butt.

IV.—When firing shrapnell.—The bugle sounds hitherto used are to be discontinued, and the telegraph system is to be brought into play, as with other practice.

The *white* frame inclined *outwards*—
  Once: indicates an interval* of 25 paces.
  Twice: „ „ 50 „ and so on.

The *white* frame inclined *inwards*—
  Once: The projectile has burst close in front or between the targets.†
  Twice: „ „ behind the targets.
  Thrice: „ „ 100 paces „ „

The *red* frame inclined *outwards*—
  Once: A height of explosion of 5 feet.
  Twice: „ „ 10 „ and so on.

The *red* frame inclined *inwards*—
  A height of explosion of 0 feet, or that the shell has exploded on the ground.

If the shrapnell grazes before bursting, or if the fuzes does not burn, there is no telegraphing required. In case of any great deviations from the line of fire, the details above given for the like object hold good.

Remark.—Especial care, in firing shrapnell, is to be taken that no piece be fired—firstly, until the flag at the look out post is lowered, for each round has to be observed and its

* These terms are thus defined in a Prussian work:—" The *interval of the explosion* is the horizontal distance of the point of explosion from the object. The *height of the explosion* is the perpendicular distance of the point of explosion above the ground.

† The objects fired at in shrapnell practice consist of three targets, 40 paces long, placed at 20 paces distance, one behind the other—the first being 9 feet high, representing the front of a cavalry column, the other two being 6 feet high, standing for infantry in rear.

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height of explosion, &c., estimated separately; and secondly, until the bugle at the battery shall have sounded "load."

The above comprises the whole of the telegraphic system. It is simple, easily understood by men of all grades, and seems in practice to have met with unanimous approval.

To resume the heads of the index—

8. *Batteries to be thrown up.*

Under this head I find that the number of batteries, &c., to be thrown up are—

(1.) Dismounting-battery at 600 paces, for 4 pieces.

(2.) A powder magazine for the same.

(3.) A sunken ricochet-battery against the terreplein at 800 paces, for 2 howitzers.

(4.) A powder magazine for the same.

(5.) An oblique ricochet-battery constructed in the parallel, which is cut by the line of fire at an angle of between 70° and 75°.

(6.) A breaching battery for 2 guns.

(7.) An experimental battery of 2 embrasures.

9. *Employment of time during the practice season, with indication of each day's battery-practice.*

This section contains a complete *exposé* of how each "division" is to be employed, whether at mounted exercise, preparing ammunition, constructing the battery depôt, arming batteries, preparation of battery materials, fascines, gabions, &c., or manœuvring with men carrying flags to represent any enemy's regiments of cavalry or artillery, throwing up batteries and field works, Commanding Officer's and Inspector's reviews, or in battery practice, when every possible detail is given as to each day's practice.

10. *List of Committees, with data regarding the reports to be furnished by them, &c.*

The first of these is a standing committee, whose duty it is to make such purchases for government as may be requisite, and to keep and render the accounts of such transactions.

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The second has to pass an opinion upon a new model quick-match-tube.

The third has to deliberate on a new model howitzer shell-bottom, and on some changes in packing ammunition.

The fourth has the task allotted to it of carrying on certain experimental practice.

11. *Experimentol practice.*

This section contains a short list of experiments which are directed to be made—such as the effect of shrapnell from heavy guns—the effect of a slight rise of ground in giving cover to a field battery, &c.

12. *General orders for the regiment during the practice season of* 1856.

This section contains twenty-five pages of matter, of which a general notion will be formed from the following heads:—Issue of the parole; dress; mounted exercise; receipt of ammunition; taking over charge of the depôt ordnance; range sentries and distance measurers; daily duty; rounds; recovery of shot and shell; instruction; fatigue parties; damage to fields; police regulations; filling up holes; mantlets; presentation of reports and memoirs; drinking water; military order; shoeing of horses; breakfast; guards and their duties; bathing; practice reports and books; and, finally, general subjects.

13. *Method of posting the range sentries.*

14. *Extract from the standing orders regarding the posting of the range sentries.*

Here is detailed the exact position of each sentry and his duties, illustrated by a plan.

15. *Forms of reports to be furnished daily from batteries and companies.*

16. *Forms of practice reports.*

17. *Distribution of the field guns.*

18. *Distribution of the officers, men, and horses in cantonment.*

19. *Distribution of guards.*

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The last five heads sufficiently explain themselves. The details under each of them are of the most minute character.

You will now be able to form an accurate notion of the system with which the practice duties are carried on. I shall proceed to give you the result of my own observations on certain matters which I had an opportunity of personally inspecting. I was told that the day of my visit was a peculiarly unfavourable one. It might be so; but it was one of great interest to me.

Colonel Podevils, to whom I had the honor of being presented, at once granted permission for me to inspect everything, and to mount an officer's (my friend's) horse. I found 44 horsed guns drilling, or eleven batteries on the peace establishment; three were horse artillery, the remainder were foot artillery. One of the first things that struck me was the squareness with which each movement was made. This is to be accounted for partly from the *matériel* itself and, undoubtedly by the care with which the men are drilled. As to the *matériel*, if the pole of a piece of artillery of the model of 1842, which is now in use, be turned to one side to such an extent that the limber wheel touches the friction plate on the trail, the angle formed by the pole, and a line bisecting the axletree of the piece itself, and consequently equidistant from the wheels of the piece, varies between 83° and 85°.* This enables a gun to be turned very sharp, and consequently it is not necessary in manœuvre to gain much ground in the changing direction of the front.

The system of draught is that of the pole. The limber, however, is provided with a perch, on the end of which is the limbering hook. The balance of the pole with the limber box filled with ammunition is so regulated, that the weight of the pole borne on the wheelers' necks is only twenty-pounds. The chain connecting the collars of the wheelers to the pole, is about 3 feet in length; the pole has thus considera-

* This angle in British field artillery varies between 45° and 47°.

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ble play up and down. By the construction of the *matériel*, the play is as much as 26° above, and 16° below the horizontal line, but when the teams are yoked it is much less. This looks very awkward, but it appears to present no inconvenience in practice.

The accuracy of alignment in changes of front struck me with admiration. Nothing but persevering practice and good instruction could have ever attained such a result.

Some of your readers may be aware that the wagons in the Prussian artillery do not form a portion of the manœuvring body. With the foot artillery, then, it was necessary to make some arrangement to carry the men in quick movements. This has been done in a manner well worthy of imitation. The off horses are provided with pad-saddles and stirrups of such a construction as to admit of a man riding on them for short distances with ease. In quick movements, three men mount the off-horses, getting up with the right foot in the stirrup; the drivers on the near horses lend them a hand, and the men mount with facility and expedition. They are directed to hold on by both hands, one in the mane, the other at the pommel of the pad. The other three men of the gun's-crew mount on the limber-box, and the non-commissioned officer in charge of the piece has his own riding-horse. This system has been copied by the Sardinian foot artillery, and I have been informed by an officer of that army that it is found to answer perfectly in practice.

The horse artillery batteries were equally the subject of my admiration, though they presented less novelty to me than the foot artillery. The detachment system obtains—each detachment of eight men riding in *rear* of the piece, the odd numbers being in front and the even in rear, Nos. 7 and 8, or the left file, being horse holders. The movements were performed with every possible accuracy, and a gallop in line for some two hundred and fifty yards, followed by a sudden halt, found all the pieces in perfect line. In the trot, out

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of the twelve teams not one horse cantered. One manœuvre was new to me, it was certainly very pretty, might be useful, but possibly would be a little dangerous. It consisted in reuniting the detachments of the three batteries one hundred yards in front of the guns at a gallop; then forming into a squadron of cavalry, advancing, and charging. Meanwhile, the guns retreated two or three hundred yards, unlimbered, and loaded, the latter operation being performed by the middle and wheel riders. The squadron then retreated to the guns at a gallop, the horses, in their eagerness to rejoin their comrades, going *ventre à terre*. The attack and retreat is sometimes made in extended order; in the latter, each man rejoins his piece at full speed independently.

Drilling with these batteries, I found one Swedish, one Prussian hussar, and one lancer officer. The two latter were, of course, attached to the horse artillery.

I next visited the batteries and magazine. I had thus an opportunity of seeing some mortar practice, and every species of ammunition and store. In the mortar battery I found a newly invented quick-match tube in use, which, for economy and efficiency, appears to me to be well worthy of consideration. It is termed "*Papier-stoppine*." The accompanying figures will, with the subsequent description of the manufacture of the first, give you every requisite information on the subject.

The "*Papier-stoppine*" (Fig. 8, Plate 26) is composed of a paper tube enclosing a piece of quick match. A sheet of paper is rolled round an iron former and pasted, thus forming a case 8* inches long and 0·23 inch in diameter. The addition of a small quantity of clay to the paste prevents the tube from burning in the vent after being fired. The case is cut at one end in a triangular shape. The quick match over-tops the case by about 3 inches, the end thereof is bent over into the triangular notch alluded to. The quick match is kept in this

* In British imperial measures 8·232 in. long, and 0·239 in. in diameter. The Prussian vents are 0·257 in. diameter. British vents are 0·222 in. in diameter.

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position by a band of thin paper, *a, b, c, d,* pasted to the tube, without, however, sticking to the match itself. The object of the strip of paper is merely to prevent the quick-match from falling out of the case; the portion of the case *e, f, a, c,* is intended to protect the match from injury. This tube is intended to be used both in and before a fortress. It is *instantaneous* in action, and may be fired with either port-fire or lint-stock.

Fig. 9 shows the quick-match tube as I saw it used at Wahn. It appears to be an improvement on the former.

This tube and its description may appear to be matters of extreme detail. Be it so: but they are of no small importance. Our mortars are usually fired with a simple strand of quickmatch; and the consequence is, that very frequently the charge is not inflamed at once, the match burns slowly, seems to have become extinguished, and eventually either does or does not fire the charge. In the latter case it is always a service of danger to go up to the mortar, to serve the vent, and affix a fresh quick-match; indeed, I know cases in which lives have been very nearly lost, by the ventsmen or an imprudent but zealous officer going up to a mortar under such circumstances. It will be obvious that the friction-tube cannot be safely used with any but the largest mortars, as the drag requisite to pull the rubber from the tube is, with the smaller calibres, sufficient to alter the direction. Loose powder and a portfire are no less inapplicable to this purpose, as, where the charges are small, the priming powder would materially alter the range at every round, according as a plentiful or scanty supply was put on the vent; neither is the construction of the more modern mortars calculated for such a method of firing.

As to fuzes, the only novelty I observed was the fact of the bore of the fuze being made like a female screw. The object of this is to prevent the column of composition from being knocked out by the concussion of the shell against the

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ground. Our fuzes having plain bores, never, as far as I have heard, have been found fault with in this respect; but it seems natural enough to suppose, when the composition is nearly burnt through, or when but a small portion of it is left in the fuze in firing at short distances, that the sudden jar of the shell striking the ground should have this effect. The new Boxer fuze, however, is safe against such an accident. One half of the Prussian fuze is driven with mealed powder, burning at a quick rate, and the other with fuze composition. This system makes the fuze more generally useful, whether for long or short distances. The timing of fuzes, however, is by no means so accurately cared for as in the British service.

The eccentric shells, as described in an article communicated by me, and published in your magazine for the month of April of this year,* are fired both from mortars and howitzers. The shells are received from the magazine with a cross cut on the surface with a cold chisel, marking the "light pole." This, as I before explained, is ascertained by floating the shells in mercury, and lowering a disc covered with paint on its lower side and suspended by a thread, until it touches the surface of the shell. In the laboratory, a piece of twine covered with white-lead is held in the manner carpenters strike a chalk line, one end being at the light pole, the other so that the twine shall bisect the fuze hole, and the line struck. The light pole end of this line is then formed into an arrow-head. A second line is struck at right angles to the first, forming portions of two great circles; the one being polar, the other equatorial. The face of the mortar is similarly marked with two lines at right angles. The shell is then lowered into the piece, and the paint lines on the shell made to coincide with those on the mortar, care being taken to place the arrow-head upwards or downwards, according as it may be desired.

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* Artillery Records, page 455, head "Selections."

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Each mortar-bed is provided with an iron plate attached to the front transom, having a semicircular cut made in it exactly in the axis of the bed. This cut is made to fit a bolt driven into the platform, so that the bed and mortar, when traversed, move upon this point as a pivot. On the rear transom is a scale of inches and tenths in white paint. A centre line is made on the platform, and after the mortar has been laid by the plummet a note is taken as to which line of the scale coincides with the platform centre. The piece may thus be brought accurately to the same position after each round, or its position may be gradually corrected by means of the scale.

As another detail, and a very important one, I may mention that every piece, whether gun or howitzer, has a small flat surface planed on the first reinforce, some two inches wide by 5 or 6 inches long, which is *exactly parallel to the axis of the piece*, and to the plane bisecting the trunnions. This is, of course, executed before the piece leaves the foundry. Provided with this, any piece not having a tangent scale, or whose tangent scale has been lost or broken, may be elevated accurately, without sending a man into the embrasure, as is necessary with our heavy pieces. With us this is necessary, as the arm of the elevating quadrant has to be placed in the bore, and the elevation read off the divided limb.* A much handier instrument is shown in the sketch, Fig. 10 (drawn to half size).

It consists of a right-angled triangle of brass, having plates, (*a*, *b*, *c*,) attached to the sides containing the right angle, perpendicularly to the plane of the instrument. At *d*, a spirit level is fixed by a screw, the other end of which (the level) is terminated by a nonius. The spirit level works on *d* as pivot, and can be fastened at any given point by a thumb screw at the back (not visible in the figure). The instrument is graduated into half degrees, and seven half degrees on the

* I here allude to guns having no quarter-sights, of which there are many.

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nonius are divided into 8 parts, so that the one-sixteenth of a degree may be read off on the instrument. The length of arc for 1° is $\frac{7}{400}$ of the radius.

By placing the side *a, c* on the plane cut on the piece, and moving the level until the bubble settles in the middle of the tube, the elevation, if less than 45°, may be accurately ascertained. On the other hand, if the elevation be greater than 45°, the side *b, c* is placed on the plane aforesaid, and 45° added to the reading.

While on the subject of elevation, I may mention that all the new model guns have a line of metal parallel to the axis of the piece. This is effected by leaving a dispart patch on the muzzle, or second reinforce of the pieces, according to their nature. Different from the dispart sights on our howitzers, all field guns have a patch ending in a moderately sharp edge, over which the line of sight runs. This seems to be more approved of than a notch in the patch. The advantages of the system are very great. For our tangent scales are of no use exactly where they are most required, namely, in giving elevation from 0° to 1°.

I have thus noticed several details. Let me now for an instant draw your attention to more general matters. I found here a body of officers, all of whom have received a first-rate scientific military education before entering the corps, whose acquaintance with every imaginable practical detail was obvious. Indeed, it could hardly be otherwise. Twice a-year they have the training of recruits : the mere drill takes six months. After this period the men join their various batteries, and learn driving and the drill of the field battery. At the end of the first year they go to the practice ground, where they are worked, *tout bonnement*, like horses. Every-thing is carried on as though their enemy were present. Every-thing about the practice tends to this one point. Drill is not drill simply as the object to be attained ; it is considered as a means ; the object being the destruction of an enemy. The targets, or

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objects fired at, represent the said enemy in various positions—whether he stands in the open field, or is covered by a fortress or field works. After three years service the recruit returns to his home, but is in the first class of the Landwehr, and has so many days' drill and practice annually. He next goes to the second class of the Landwehr; but he is at all times a soldier—a soldier for life—with no possible means of escaping service should he be called upon. The severity on this point is extreme. I heard of a case of a gentleman, who had established himself in Calcutta in a house of business, beii g compelled to return to his country to serve the regulated number of years, as he had left unprovided with the proper passport for expatriation. Consider, then, that the whole of the male population of the country capable of bearing arms are soldiers; and that in 1850, on the mobilization of the army, it appeared that the whole of the infantry reached their garrisons twelve days after the issue of the order for the increase to the war establishment, ready to advance on an enemy; and that in fourteen days the cavalry, artillery, and pioneers were similary at their posts. This will give some idea of the continual state of preparation for war the Prussians are in., It appears to me to form no inconsiderable contrast to our position in the spring of 1854.

As to the artillery officers themselves, they are everlastingly at work. Their mode of life is no sinecure, such as it is sometimes in an army that I wot of. Every day they have some duty to perform, and it generally lasts nearly the whole day. Once a week there is a Reunion of officers—attendance being compulsory—at which the colonel of the regiment presides. It is not like a mess dinner exactly, nor is there much champagne or hock drunk, or cigars consumed. No; the matters for discussion are somewhat drier. The officers are invited to discuss novelties in the science of artillery; whether originated abroad or at home, whether they are original or the fruit of other brains, it matters not; each officer

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must lay before his comrades his budget. If no one volunteers a subject for discussion, the officers are compelled to do so in rotation. The effect of this must be good. The shame of being a blockhead, or of being thought so, would induce many a man to read and think, who would otherewise not exert himself in the matter. The colonel, too, has thus an opportunity of knowing the military capacity and *Forte* of each individual—knowledge which may be eminently useful in the field.

Before closing this letter, I cannot refrain from here recording my great sense of obligation to the Colonel and Officers of the 8th Regiment of Prussian Artillery, who received me *en bon camarade*, and were untiring in answering my manifold questions, and showing me every thing which could interest me; nor do I despair, Sir, of this method of returning my thanks reaching them, for Prussian officers are in the habit of reading everything, home-grown or foreign, which touches upon military matters. Would that so much could be said for the officers of our army!—Yours faithfully.

M. L.

To find the length of Tangent Scale for any number of degrees.—Communicated by Lieutenant G. Carleton, Adjutant and Quarter Master 4th Battalion Artillery,—Secunderabad 28th April 1857.

To the Director Artillery Depôt,

"Yesterday my Artillery Records for March arrived, and in it I read something about Tangent Scales. I never saw to my knowledge a plain practical method laid down for determining their length to various degrees. I have written out what seems to me a simple method which I was taught at home; perhaps you may think it worth putting in?"

(Signed) G. Carleton.

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To find the length of tangent scale for any number of degrees by table of either natural or logarithmic sines, tangents &c.:—first by Natural tangents:—

RULE.—Multiply the length of gun (or radius) in inches by the natural tangent of the degree for which length of scale is being determined, the product will be the length of scale required for an elevation of gun to said degree.

EXAMPLE 1.—Required to find by table of natural tangents &c. the length of scale to elevate a 9 Pdr. brass gun one degree,

1° Natural tangent....................	·0174551
Length of gun in inches..........	68·5
	1·19567435

here then we have 1·19567 &c. inch as the length of scale, above upper surface of base ring, required to elevate a 9 Pdr. brass gun 1°, supposing there is a dispart fixed on the swell of the muzzle.

EXAMPLE 2.—Required the same by logarithms,

68·5 inches.........................log.	1·8356905
1° log. tangent......................	8·2419215
Natural number 1·19567......	0·0776121

here then we have the same result.

NOTE.—Should there not be the dispart cast or fixed on the muzzle of the gun, it must be determined and allowed for by deducting it from the length of scale as just found, should it exceed any calculated length of tangent scale, the difference, or its excess will be the distance the degree on the tangent scale will be below the upper surface of the base ring.

Suppose for instance in the above example the dispart to be 1¼ inch;—take 1·25 from 1·19567 the remainder 0·05433 inch is the depth which the top of tangent scale should be

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below the upper surface of base ring, which practically is naught.

In like manner is found the length of tangent scale for two degrees.

68·5 inches	log.	1·8356906
2°	log. tangent	8·5430838
Natural number 2·392		0·3787744

here we have the length required 2·392 inches which the top of the tangent scale should be above base ring of 9 Pdr. gun, to elevate it 2 degrees; but in case there be no dispart fixed on the muzzle, supposing the actual dispart to be 1·25 inch; take 1·25 from 2·392 and the difference 1·142 inch will be all that should remain of the tangent scale above the base ring when elevating the gun two degrees, and the scale would be marked at that distance from its top for 2 degrees elevation; in like manner length of scale may be calculated for any degree or parts of a degree.

(Signed) G. Carleton.

Theoretic Analysis of the relative efficiency of Light Field Guns and Howitzers.—Communicated by Lieutenant G. Carleton Adjutant and Quarter Master 4th Battalion Artillery.

" I send you a few remarks on guns and howitzers; I dont know whether you will agree with them or not, but perhaps if published in the Records they might interest some in the Corps to either refute or corroborate. I have never seen the matter treated of in the same way before."

Secunderabad, May 1857.

Theoretic Analysis of the relative efficiency of Light Field guns and howitzers.

Multiply the weights of gun and howitzer (carriages and limbers inclusive) by their lengths respectively, and these

products again by the ratios of resistance of their shot and shell inversely.

	cwt.	qrs.	lbs.		cwt.
6 Pdr. Gun, weight..................	27	3	20	or...	27·928
Length of gun in feet........................					5
Weight × Length...=					139·640

Ratio of shell's resistance 115·87 × 139·640=16180·086 merit of gun.

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	cwt.	qrs.	lbs.		cwt.
12 Pdr. howitzer, weight..........	31	3	0	or...	31·75
Length of howitzer in feet......					3·75
Weight × Length...=					119·0625

Ratio of shot's resistance 102·4 × 119·063=12192·05 merit of howitzer.

The resistance of atmosphere against projectile being directly as the surface and inversely as the weight, and surface being as the square of its diameter, the above ratios are found thus :—

Diameter of 6 Pdr. shot $(3{\cdot}58)^2$ inch=12·8164 ratio of shot's surface.—Diameter of 12 Pdr. howitzer shell $(4{\cdot}54)^2$ inch=20·6116 ratio of shell's surface.—Then ratio of shot's surface 12·8 &c. × shell's weight or 8 lbs.=102·4 ratio of shot's resistance,—and ratio of shell's surface 20·6 &c. × 5·625 *i. e.* shot's weight=115·875 ratio of shell's resistance;—and relative value of gun 6 Pdr. to howitzer 12 Pdr. is nearly as 4 to 3.

According to the same mode of investigation, the merit of the 9 Pdr. gun, compared with that of 24 Pdr. howitzer. would seem proportionally greater.

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	cwt.	qrs.		cwt.
9 Pdr. gun, weight......................	33	3	or...	33·75
Length of gun in feet....................				5·71
Weight × Length......				192·7125

Ratio of shell's resistance 275·4 × 192·71 = 53072·33 &c. merit of gun.

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	cwt.	qrs.	lbs.		cwt.
24 Pdr. howitzer, weight...........	35	2	0	or...	35·5
Length of howitzer in feet............					4
Weight × Length......					142·0

Ratio of shot's resistance 268·96 × 142·0 = 38192·32 merit of howitzer; here then we have 9 Pdr. gun : 24 Pdr. howitzer : : 5 : 3 nearly.

The ratios of resistance of atmosphere to shot and shell are found as in the preceding example.

The weight assumed for guns and howitzers, are those published in the Gunner's Assistant in 1849, as the average weight of gun, carriage, and limber, without ammunition.

The foregoing analysis would lead one to infer, that a proportion of howitzers to guns of one-third is rather great, especially, when several batteries take the field together.

(Signed) G. Carleton.

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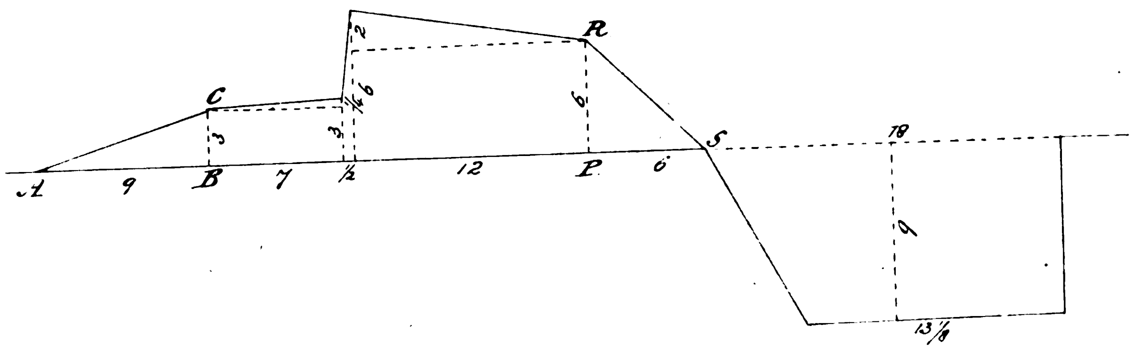
Miscellaneous



Scale. 10 feet to an inch

J B.

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On the construction of field works as far as regards the determining of depth and breadth of ditches in elevated batteries &c.—Communicated by Captain G. Carleton Adjutant and Quarter Master 4th Battalion Artillery.

"I send you a few remarks on the calculation for breadth or depth of ditches in field works, and the manner of determining scales in plotting &c.—I have never found the same clearly laid down in books, and yet they are useful to know. Lefroy has very good remarks on field works, but says nothing about the way of fixing at once upon depth or breadth to dig a ditch to."

Secunderabad, 4th June 1857.

Area of proposed parapet being found and depth to which ditch is intended to be carried having been determined, it is required to know what breadth should be given to ditch at top and bottom.

Rule.—Divide the double area of parapet by the depth of ditch, and the quotient will be the sum of widths at top and bottom.

1st. To find the double area of parapet (Plate 27) $9\times3=27$, and $6\times6=36$, the double areas of the triangles A, B, C, and P, R, S.

$$\left.\begin{array}{l}(3+3\tfrac{1}{4})\times7=43\tfrac{3}{4}\\(8+3\tfrac{1}{4})\times\tfrac{1}{2}=\ \ 5\tfrac{5}{8}\\14\times12\qquad\ =168\end{array}\right\}$$ The double areas of the three trapezoids, into which the section or profile is divided by dotted lines.

then $27+43\frac{3}{4}+5\frac{5}{8}+168+36=280\frac{3}{8}$ the double area of profile.

Now knowing the area of parapet, I choose 9 feet as the depth of ditch, which divided into the double area $280\frac{3}{8}$ will

give the sum of widths of top and bottom of ditch:—thus $\frac{280\frac{3}{8}}{9}=31\frac{1}{8}$ the sum of widths of ditch at top and bottom, then if the top width is required to be 18 feet, the bottom can only be $13\frac{1}{8}$ feet broad, and vice versâ if the widths at top and bottom together be 31 feet, then the depth of ditch is found by dividing the double area by this 31 feet.

To determine the scale upon which the accompanying diagram (Plate 27) is drawn from any scale of equal parts, say from scale of 40, or 40 equal parts to 1 inch:—it is found on measurement that 16 feet, for instance, in the diagram measure 64 divisions on scale of 40, *i. e.* $\frac{64 \text{ feet}}{40 \text{ feet}}$, then to find a horizontal scale of section, say $\frac{64}{40} : \frac{40}{40} :: 16$

or, $64 : 40 :: 16$

or, $8 : 5 :: 16$

i. e. $\frac{16 \times 5}{8} = 10$, therefore the scale on which the diagram is drawn is 10 feet to 1 inch;—the vertical scale, were it different and required to be found is discovered in the same way.

A scale of 40 yards to 1 inch, how many inches to a mile? in a mile are 1760 yards, it will be as $40 : 1760 :: 1 : 44$, *i. e.* 44 inches to 1 mile.

To regulate the scale upon which any diagram, or say a survey of country is plotted according the size of one's paper. Suppose paper be 20 inches by 36 and I want to plot on it 6 miles by 2. I divide the number of yards in 6 miles, or 10560 yards by the length of paper or 36 inches, which gives $293\frac{1}{3}$, or nearly 300 yards to 1 inch, in like manner for any size paper.

(Signed) G. Carleton.

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An enquiry into the amount of weight drawn and carried, by the several Horses in a 6 Pdr. Gun and 12 Pdr. Howitzer Madras Horse Artillery.—Communicated by Captain G. Carleton, Adjutant and Quarter Master 4th Battalion Artillery.

6 POUNDER GUN.

	cwt.	qrs.	lbs.	lbs.
Weight of Gun taken from 6th Edition Gunner's Assistant.............	6	0	0	
Do. Carriage, Do.	9	2	18	
Do. Limber Do.	10	0	0	
	25	2	18=	2874
Do. Ammunition and Stores...	4	2	24=	528
Total weight of Gun, Carriage, Limber, Ammunition, and Stores.......	30	1	14=	3402

For the present the weight drawn only will be considered, viz. 3402 lbs. omitting decimals, and applying General Von Scharnhorst's estimate, that the centre pair in a team of six, only draw $\frac{5}{6}$ of what the wheelers do, and the front pair $\frac{5}{9}$ of the same, and this too in the old counterpoise carriages, in which the horses were more equally yoked for draught,* we say:—

Let x=pole horses' share, then will

$\frac{5x}{6}$=Centre „ „ and

$\frac{5x}{9}$=front „ „ and

$\therefore \; x+\frac{5x}{6}+\frac{5x}{9}$=total draught weight=3402 lbs.

$43x=61236$

$x=1424$ lbs. the weight drawn by the pole horses, and supposing them to draw equal shares, which they do not, the near horse being mounted :—

	lbs.
each pole horse's share in draught will be...............	712
each centre horse's share $\frac{5}{6}$ of this, or omitting decimals.	593
and each front horse's $\frac{5}{9}$ of the same, or....................	396

* The established Pattern Limbers are counterpoise *i. e.* have the short Perch in rear, and the horses are yoked as of old.—Ed.

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Now let us consider the weights carried.

	Stone.	lbs.	lbs.
Weight of driver in marching order prepared to mount.	11	0	=154
„ „ saddle, bridle, head rope, deducting line articles....	3	11	= 53
„ „ pole on collar $2\frac{1}{2}$ Stone each, and harness 2 St. 12 lbs...	5	5	= 75
Total weight carried by near pole horse.	20	2	=282

No forage is here included, and the weight of man without arms &c, is taken at only 10 St. 5 lbs., which was the average weight of the men of the D. Troop in 1851.

	St.	lb.	lbs.
Total weight carried by off pole horse including double set of line articles, harness, and weight of pole on collar...	8	5	=117
Total weight carried by near centre horse....	17	7	= 245
„ „ „ „ off „ „ ...	5	7	= 77
Total weight carried by near front horse.....	17	7	= 245
„ „ „ „ off „ „ ...	5	7	= 77

	cwt.	qrs.	lbs.
Total weight drawn by team of 6 horses.......	30	1	14
„ „ carried „ „ „ 6 „	9	1	7
Total drawn and carried.........	39	2	21

To these weights carried if we add those drawn we get

	Weight drawn lbs.	Weight carried lbs.	lbs.
Near pole horse...	712+	282	=994
Off „ „	712+	117	=829
Near centre „	593+	245	=838
Off „ „	593+	77	=670
Near front „	396+	245	=641
Off „ „	396+	77	=473

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N. B. Weight of two Limber men say 20 St. 10 lbs. is not here counted, as they are not usually carried in marching order, though in the field, circumstances might occur to render such necessary.

The daily labour of a draught horse is calculated by French authorities at 864 lbs. (or nearly 7¾ cwt. English) drawn 21 miles; and the Light Cavalry horse in France is calculated only to carry about 198 lbs. or 14 stone 2 lbs., but the horse can transport in draught about 3.7 as much as he can carry, even on indifferent roads travelling at a walk; therefore each Artillery horse should be calculated to draw, the French calculate 330 to 333 Kilogrammes, or from 728 to about 734 lbs. English, though these weights are counted excessive for Artillery, required to manœuvre with Cavalry.

The maximum weight a Horse Artillery horse, carrying a rider, should be called on to draw, has been laid down, by English authorities at about 500 lbs., this, is calculated, be it remembered, for horses of about 16 hands high, and 80 inches girth round the chest, and taking the weight of driver at 12 stone, the average weight of horse also being taken at 11 Cwt., whereas the average weight of horses in India is said to be 8½ Cwt., their girth not above 70 inches on an average taken from gun horses only, and the average height taken also from gun horses not above 14 hands 3 inches.

Now if we compare weights drawn by the several near horses in our 6 Pdr. Horse Artillery Gun with the maximum above laid down, we get the following.

	lbs.
Near pole horse excess in draught, weight on	212
,, centre ,, ,, ,, ,, ,, ,,	93
,, front ,, difference in favor of	104

and for the off horses of the team, taking 728 lbs. as the maximum weights to be imposed in draught.

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		lbs.
Off pole horse difference in favor of......		16
,, centre ,, ,, ,, ,, ,, ...		135
,, front ,, ,, ,, ,, ,, ...		332

Ratio of draught on the several pairs in a team of six horses and in a 6 Pdr. gun.

$x : \frac{5x}{6} :: \frac{5x}{9}$, x being $=$ the draught power of pole horses, then we have the ratio of pole to centre

$54x : 45x :: 30x$

$18 : 15 :: 10$ As $18 : 15$ or 6 to 5.

and of pole to front horses $18 : 10$ or 9 to 5.

and of centre to front, as $15 : 10$ or 3 to 2.

hence front pair only draws $\frac{2}{3}$ what the centre do.

In the 12 Pdr., Howitzer, the weight drawn by each pole horse is about 30 lbs. more than by the 6 Pdr. pole horse, and the others also draw proportionably more.

Dialing.—Communicated by Captain G. Carleton Adjutant and Quarter Master 4th Battalion Artillery.

"Should you think the accompanying directions for Dialing worth notice in the Records, perhaps you would kindly publish them. Having made a sun dial upon the same calculation when in Turkey, I know that they are practically correct as well as theoretically, and with a table of logarithms, any one could upon the same Rule, calculate the lines for the hour shadows; their intervals may be subdivided to half or quarter hours, and these again to minutes, and to shew the time with great exactness.

Dialing.

Rule.—To Calculate the hour lines for a horizontal South dial, Say as Radius : Sine of latitude of place where dial is to be put up :: Tangent of hour angle : Tangent of horizontal distance.

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As the earth revolves round its axis from west to east in 24 hours, or at the rate of 15° for every hour, therefore in calculating we use the Tangent of 15° for one hour, Tangent of 30° for two hours and so on; and in calculating for a very large dial to be exact, we should calculate for the half hour lines at the rate of 7½° for each half hour, saying Radius : Sine of latitude :: Tangent of 7° 30′ : Tangent

Errata in the No. for July 1857.

In page 480 of "Miscellaneous" fourth line from the bottom, *For* "Radius : Co Latitude" *Read* "Radius : Sine of Co Latitude."

In page 481 *For*, : Line 41°1′ *Read* : Sine 41°1′.—To be corrected throughout the page.

with its gnomon coincident with the true and not the magnetic Meridian. The angle of gnomon's altitude must be equal to the latitude of place in which dial is placed, and this angle is placed at the centre of the dial. In a low latitude, say 10° or 12° North or South, the 6 o'clock line should be very near the North or South side of the dial respectively, say $\frac{1}{6}$ of the diameter of its circle.

In a high latitude as 53° or so North or South, the 6 o'clock line is well placed as far as $\frac{2}{3}$ of the diameter of the dial from its North or South side respectively.

In calculating the hour lines for a *vertical* South dial, the calculation will be the same as for the horizontal dial, merely substituting Co Latitude for Latitude; thus, Radius : Co Latitude :: Tangent of hour angle, or 15° : Tangent of horizontal distance, and the elevation of gnomon will be equal to the angle of Co Latitude of dials' position.

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EXAMPLE.—Calculate a South horizontal dial for Latitude, say of Scutari 41° 1′ N.—For the 1st hour line we say.

As Radius	10.000000
: Line 41° 1′	9.817088
:: Tangent 15°	9.428053
: Tangent of hour angle	9.245141 or 9° 58′ 24″

Again for the 2nd hour line

As Radius	10.000000
: Line 41° 1′	9.817088
:: Tangent 30°	9.761439
: Tangent of hour angle	9.578527 or 20° 45′ 6″

for the 3rd hour line

As Radius	10.000000
: Line 41° 1′	9.817088
:: Tangent 45°	10.000000
: Tangent of hour angle	9.817088 or 33° 16′ 33″

for the 4th hour line

As Radius	10.000000
: Line 41° 1	9.817088
:: Tangent 60°	10.238561
: Tangent of hour angle	10.055649 or 48° 39′ 38″

for the 5th hour line, or 1 hour from the 6 o'clock line and 5 from noon.

As Radius	10.000000
: Line 41° 1′	9.817088
:: Tangent 75°	10.571948
: Tangent of hour angle	10.389036 or 67″ 47′ 25″

(Signed) G. CARLETON.

Secunderabad July 24th 1857.

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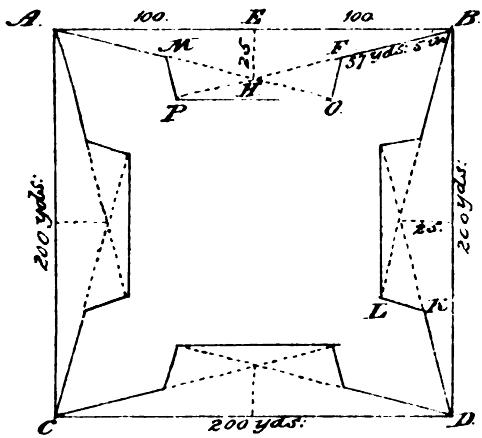
On the construction of Field works.—Communicated by Captain G. Carleton, Adjutant and Quarter Master 4th Battalion Artillery.

My dear Major,

I send you a few notes in continuation of my last* on construction of Field works, they will doubtless appear almost too trivial for insertion in a work like our Records, to many readers, but to a few, they may be interesting, and on this score only are they sent.

To trace out a square bastioned Fort:—say each side of exterior polygon to be 200 yards.



Scale. 100 yards to 1 Inch

Bisect each side as at E, and at each point of bisection erect perpendiculars inwards, each equal to $\frac{1}{8}$ of the side of polygon as $EH=25$ yards, join the inner extremities of these perpendiculars with the adjacent angles of the square, as HB, and from the angles of the square or exterior polygon set off on these lines $\frac{2}{7}$ of the length of side of exterior po-

* Pages 474 and 475 head "Miscellaneous."

lygon as BF, and let fall perpendiculars from these points on the prolongations of the lines of defence of the adjacent angles of the polygon, as FO on the line of defence AO, and MP on the line of defence PB, the line joining the points PO will form the Curtain.

To determine the scale on which diagram of Fort is drawn, from any scale of equal parts, say 8 equal parts to 1 inch.

It is found that 200 yards in the plan measure 16 divisions on such a scale, that is $\frac{16}{8}$; so $\frac{16}{8} : \frac{8}{8} :: 200$

$$16 : 8 :: \underset{\text{yards.}}{200} : \underset{\text{yards.}}{100} \text{ to 1 inch}$$

the scale sought.

Suppose it is required to raise a breast work digging a ditch 6 feet deep, the earth in breast work to equal that thrown from ditch; and suppose the area of profile of breast work is found to be 88 feet, and the slopes of ditch at each side are to be as 1 to 2, it is required to regulate the width, the ditch should be at top.

Let $ABHC$ be the profile of the breast work, and $EDPO$ that of ditch; then we have $RD=6$ feet, ER and SO both equal to each other, and each equal 3 feet.

88 we have then$=\dfrac{EO+DP}{2}\times RD=\dfrac{2\,DP+2\,ER}{2}\times 6$

or $88=(DP+3)\,6=6\,DP+18$

and so $DP=\dfrac{70}{6}=11\frac{2}{3}$ feet, the bottom width of ditch,

and the slope of ditch at either side being 3 feet in 6, or as 1 to 2, by adding the 3 feet at either side, viz. the distances ER and SO, the width of ditch at top is found, viz. $17\frac{2}{3}$ feet.

Proof $17\frac{2}{3}+11\frac{2}{3}=29\frac{1}{3}$, the sum of parallel sides of the trapezoid $EODP$.

Half the above sum, or $14\frac{2}{3}\times 6$, the depth of the ditch and perpendicular height between them giving 88 feet the area.

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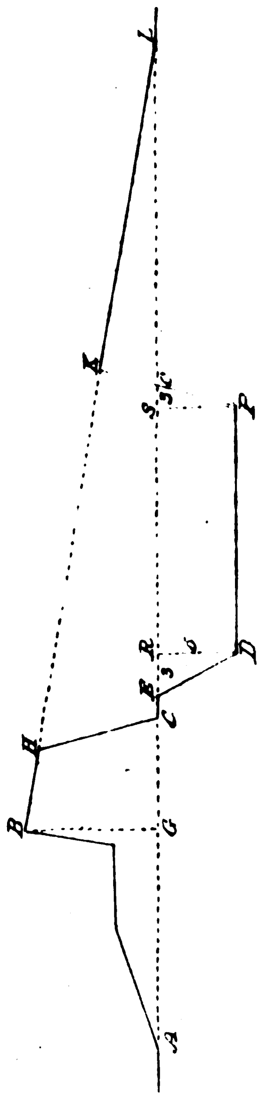
Again, what must be the breadth of ditch at top, the depth and width at bottom remaining the same, when the profile of



breastwork remains the same, and the earth in consequence of removal occupies $\frac{1}{12}$th more space than it did before it was excavated; suppose 12 feet be dug from ditch, then will there be $\frac{1}{12}$th more than 12 feet filled up by it in parapet, that is, $\frac{13}{12}$ instead of $\frac{12}{12}$.

Then we have $\frac{13}{12} : 88 :: \frac{12}{12}$ to $81\frac{3}{13}$.

Let x = required breadth of ditch at top and 3 the half depth

At Practice time, the Officer who is detailed to fix charges for the next morning's practice, has the book sent to him of the past morning's practice, or last year's it may be, and from this as a guide, he arranges his charges for the morning. I have often thought that had I no book of this kind, I would be left almost to guess-work, supposing at least I had no book at all (a thing not likely to happen you will say) I dont pretend to say there is no such rule as I have here sent, in print, but I have never seen any laid down except in the

most general terms, and this is the great fault with all books of instruction in such matters. All rules founded on theory merely, cannot of course be exact guides in practice, but I doubt if theory in this country does not come rather nearer the mark than it does at home, assuming that the atmosphere is somewhat rarer on account of the heat.

SECUNDERABAD, 8th October 1857. (Signed) G. CARLETON.

To find the charge to throw a shell a given distance at 45° elevation, weight of shell being known, and the proof charge and range at the same elevation, as also the weight of proof ball being given.

RULE :—Find the initial velocities at both the proof and required given range; then say, these velocities are as the square roots of their charges in ounces, divided by the square roots of the weights of their balls in lbs. avoirdupois; such being Hutton's proportion for velocities generated by different charges upon balls of different densities :—

Then, suppose weight of proof ball, or B.........65 lbs.
weight of proof charge, or C.........16 ozs.
weight of proposed shell, or b.....48·5 lbs.
weight of charge required.......... x.
the velocity at proof range......... v.
the velocity at proposed range...... v'.

then $v : v' :: \sqrt{\frac{C}{B}} : \sqrt{\frac{x}{b}}$; now let it be required to send an 8 inch shell,—weight 48·5 lbs. 1000 yards at 45° elevation, what charge should be used? (Referring to a memorandum made at the time, I find the charge actually used for the above at the Kamptee Practice in 1852, was 1 lb. 4 ozs. 9 drs.)

now since $v : v' :: \sqrt{\frac{C}{B}} : \sqrt{\frac{x}{b}}$

$\therefore \quad v : v' :: \sqrt{\frac{16}{65}} : \sqrt{\frac{x}{48 \cdot 5}}$

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$$\text{or }^{*}\ 235 : 310 :: \sqrt{\tfrac{16}{65}} : \sqrt{\tfrac{x}{48\cdot5}}$$

$$47 : 62 :: \sqrt{\tfrac{16}{65}} : \sqrt{\tfrac{x}{48\cdot5}} \text{ square all}$$

$$\text{and } 2209 : 3844 :: \tfrac{16}{65} : \tfrac{x}{48\cdot5}$$

$$2209 : 3844 :: 16\times48\cdot5 : 65x.$$

$$:: \quad 776 : 65x.$$

$$65x\times2209=776\times3844$$

$$x=\frac{776\times3844}{65\times2209}=\frac{2982944}{143585}=20 \text{ ozs. } 12\tfrac{1}{4} \text{ drs.}$$

nearly, the charge actually used, viz. 20 ozs. 9 drs. gave a medium range of 970 yards only.

The Rule, that ranges are at the same elevation nearly proportional to their charges, does not seem so good as the above, when the balls are of different densities : for example:—With powder 579 yards proof range with 1 lb. powder, the weight of ball being 65 lbs. and fired from an 8 inch iron mortar, I want to find the charge to throw a shell 48·5 lbs. weight 1000 yards:—

$$\begin{array}{ccccc} \text{yds. lbs.} & & \text{yds. lbs.} & \text{ozs.} & \text{ozs. drs.} \\ (579\times65) & : & (1000\times48\cdot5) :: 16 & : & 20 \,,,\ 9\tfrac{9}{10} \end{array}$$

the charge actually used, viz. 20 ozs. 9 drs., gave a medium range 30 yards short ;—it is probable, that at 1000 yards distance, a difference of at least 2 drs. more would be required.

(Signed) G. Carleton.

---

* The velocities at proof range and proposed range 235 and 310 respectively are calculated as follows.

Rule :- -To find velocity v, without having the charge C given, but the proposed horizontal range at 45° elevation, and the proof range at the same elevation being given ;—extract the square root of the impetus, which in this case, the elevation being 45°, is equal to half the range in feet, divide the square root by 4, then divide the double impetus, or range, by this last quotient, and the result will be the initial velocity.

The proof range in the above example is given 579 yards=1737 feet ; and the impetus consequently is 868·5 feet.

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Miscellaneous.

Clark's Table of Mechanical Motions.

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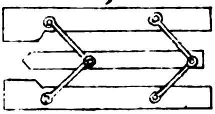

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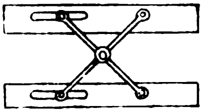

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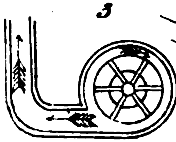

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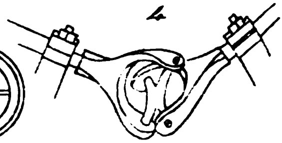

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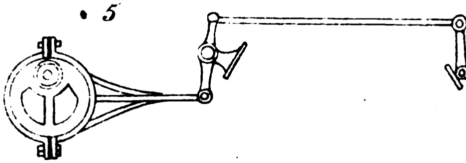

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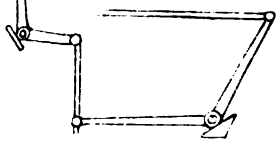

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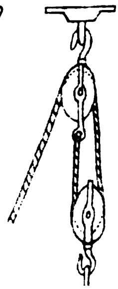

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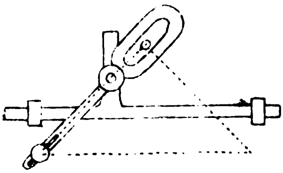

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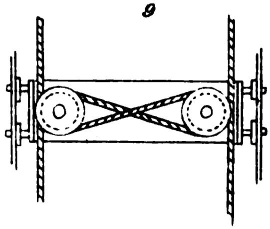

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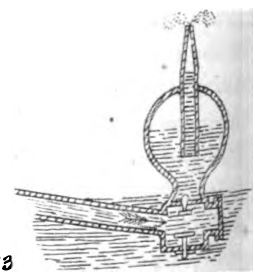

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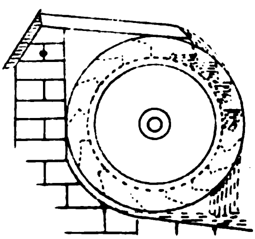

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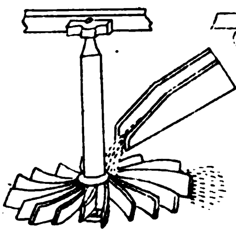

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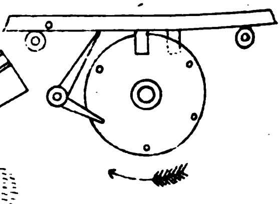

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Clark's Table of Mechanical Motions.

Figs. 1 and 2 are simple arrangements for maintaining Parallel Lines, and in ordinary use as Parallel Rulers.

Fig. 3, section of the centrifugal Fan or Pump, which when caused to revolve rapidly on its axis, draws in air or water at the centre, and throwing it off radially will impel it through the pipe, as shown by the arrows.

Fig. 4. Universal Joints for coupling shafts when such shafts are not in a straight line.

Fig. 5. Eccentric and strap, communicating a reciprocating motion to levers and cranks mounted on fixed fulcra as at Fig. 6. Fig. 7, Blocks and Fall.

Fig. 8. If the upper pin be fixed and the lower end of lever moved in the direction of lower dotted line, a horizontal transverse motion will be given to the bar in its guides.

Fig. 9. Traversing Carriage, held parallel by two ropes, which pass partially round the pullies, cross each other, and change sides.

Fig. 10. Water-ram, whereby a small fall of water is made to throw a jet a great height; arrow shows the stream, escape at lower valve, which is kept open by a spring, but closed at intervals by the stream; at the moment of closing the momentum of stream overcomes pressure in upper chamber, and opens valve thereto, and throws in a portion of water, which by the aid of an air-chamber throws up a small uniform jet. Fig. 11, an Over-shot Water wheel.

Fig. 12. a Horizontal Wheel, in which the force of the stream is caused to impinge on the blades, and so force it round.

Fig. 13, the pins on wheel by rotary motion cause the horizontal rod to traverse in one direction by contact with projections on rod, and in the opposite direction by contact with bell-crank to the left.

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Miscellaneous.

Clark's Table of Mechanical Motions

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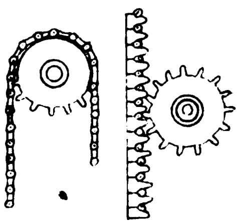

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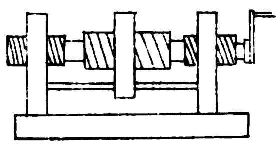

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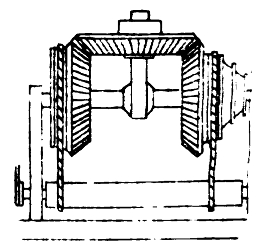

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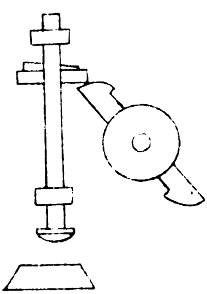

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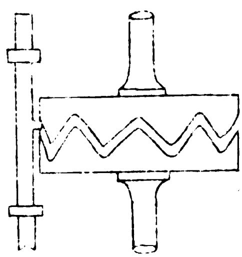

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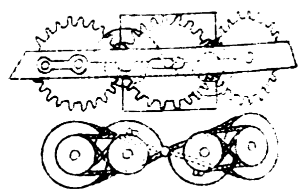

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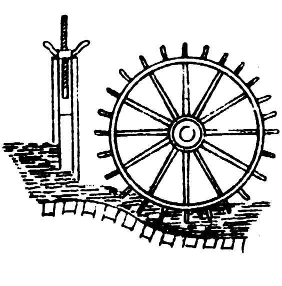

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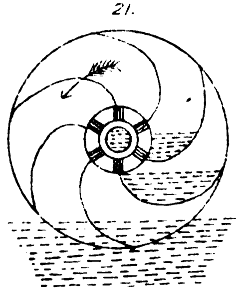

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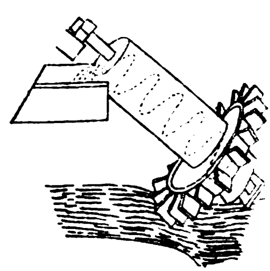

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Fig. 14, simple forms of converting rectilinear into circular motion, or the reverse.

Fig. 15. The end screws being of the same fineness, and the nut on the centre screw prevented passing round, on motion being given to the shaft, the nut will be traversed along with a speed due to the difference in the pitch of the screws.

Fig. 16, motion being given to roller below, with the bands in the position shown, the bevil wheels on the right and left will have equal velocity, and will give motion to upper wheel in position shown, but if band on the right be placed on the smaller part of the pulley, a differential motion will be imparted to the upper wheel, which will be carried round in the direction of motion of wheel to the left besides having rotary motion on its own axis.

Fig. 17, method of communicating motion to beetles for beetling linen, stamping and crushing flints, &c.

Fig. 18. Cam movement, communicating reciprocating motion to upright rod, through the stud on the side taking into the zig-zag cam groove in the periphery of the revolving cylinder.

Fig. 19. Mode of communicating an alternating rotary motion to central toothed wheel, which is supposed to gear with one of the others at a time, and is traversed in its slot bearings by large cams on pulley shafts nearest to it, and seen in lower figure, motion being given by the handle is communicated uniformly to the four pullies and their shafts, and endless bands, an alternating rotary motion will be induced in centre wheel. Fig. 20. An Undershot Water-wheel.

Fig. 21. Wheel working in a stream running from left to right carries the wheel round while the involute form of its arms or blades lifts the water as shown, which passes away through the hollow axis at an elevation above the stream.

Fig. 22. Another form of Wheel for lifting water from a stream. The stream takes effect on the blades of wheel

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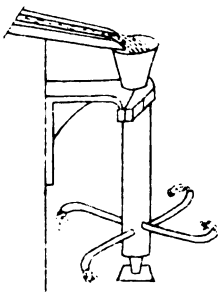

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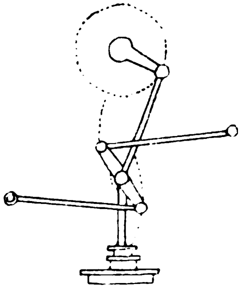

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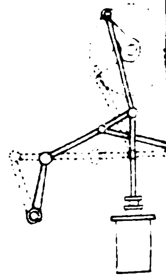

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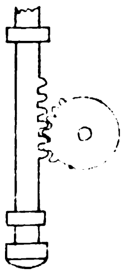

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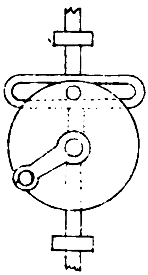

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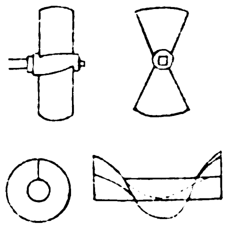

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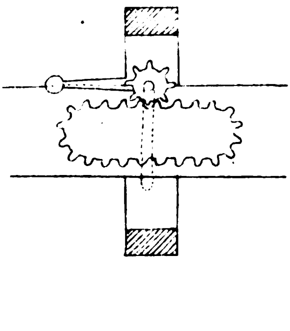

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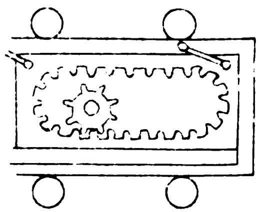

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while a screw in the hollow trunk or centre, dipping into the stream, carries a proportion of the water to the top, as shown.

Fig. 23. Reaction or Barker's Mill for taking advantage of a small quantity of water falling a considerable height, the emission apertures being regulated to maintain the vertical cylinder full, the reaction of the water in its escape forces the arms and cylinder round in the opposite direction.

Fig. 24. Parallel Motion for converting reciprocating into rotary motion. Horizontal radius rods jointed to fixed pins at extreme ends, are connected to opposite ends of oscillating link, mounted on connecting and piston rod joint, which is thus constrained to move in the vertical line.

Fig. 25. Modification of the above, easily traced by examining the dotted lines.

Fig. 26. The shaft and segment having rotary motion, lifts the vertical rod or hammer, which falls again when the teeth quit their hold.

Fig. 27. Rotary Motion being given to disc, the pin near its periphery takes into the horizontal slot in upright, which is moved up and down to nearly the extent of disc's diameter. The reverse of this motion is the common donkey engine for feeding boilers, the one end of upright being the piston rod, and the other the pump rod, with the fly wheel on the rotating disc shaft.

Fig. 28. Screw Propeller, the lower one shows a complete turn of the screw, while the upper engraving shows the section thereof in general use.

Fig. 29. Alternating traverse motion of toothed segment produced by continuous motion of pinion in one direction, whose axis is guided by slot shown in dotted lines, permitting it to pass round the ends of toothed segment.

Fig. 30. Alternating Traverse Motion where the pinion is in fixed bearings, the segment of teeth being suspended by links, but confined by external frame.

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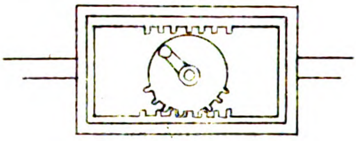

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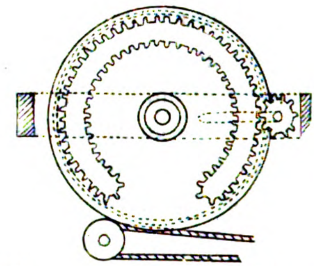

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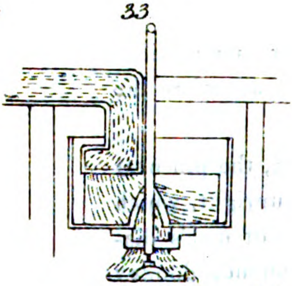

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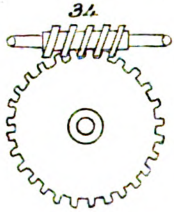

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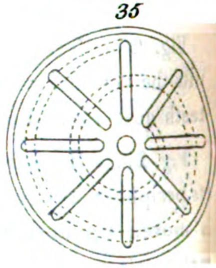

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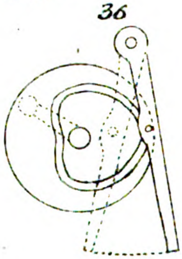

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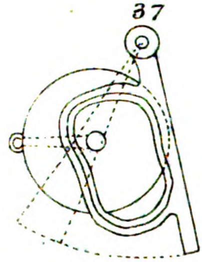

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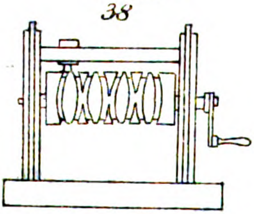

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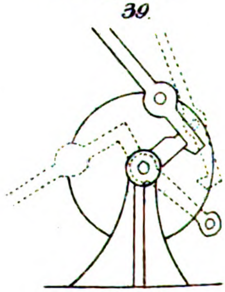

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Fig. 31. Alternating Traverse Motion by segment of teeth taking into two racks alternately.

Fig. 32. Reciprocating Rotary Motion produced by continuous rotary motion of pinion working, a modification of Fig. 29.

Fig. 33. Drum on vertical shaft has radial divisions against which the stream of water impinges in an oblique direction causing the drum to rotate while the water escapes at the centre.

Fig. 34. Endless screw and screw wheel, rapid rotary motion communicated to screw induces a slow rotary motion of wheel, or *vice versa*.

Fig. 35. Two discs on same shaft, one with radial slots and the other with spiral slot as dotted, bolts passed through both plates at the points of intersection of slots will be carried to or from the centre by circular motion of one plate.

Fig. 36. Cam Movement with cam groove in face of rotating disc, moves pendant arm, by pin therein taking into cam groove.

Fig. 37, similar motion with pin on rotating disc and cam groove attached to pendant arm.

Fig. 38. The right and left hand screw cut on the barrel, induces an alternating traverse motion in tooth taking into screw; the motion of barrel is continuous in one direction.

Fig. 39. If a chain be carried partially round the disc (loose on the shaft) and the end fixed thereto, the chain will be alternately wound up and released by the projection fixed to the rotating shaft, which takes into the catch lever as shown jointed to the periphery of disc; on arriving at dotted position to the right, a fixed incline disengages the catch lever, when disc runs back with lever as dotted on the left, and is again caught by the projection at the succeeding revolution; adapted for pumping where weight of pump rods depend from the chain, or where equivalent weight will carry it back.

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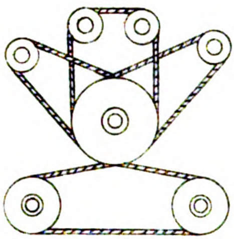

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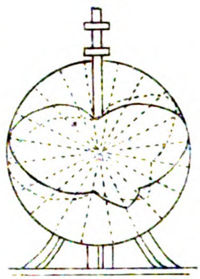

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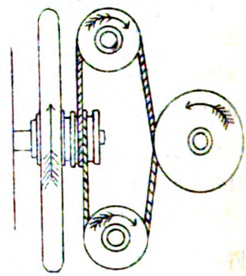

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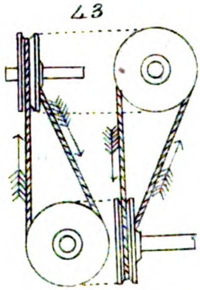

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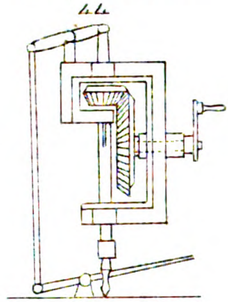

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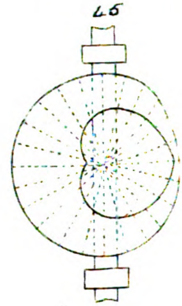

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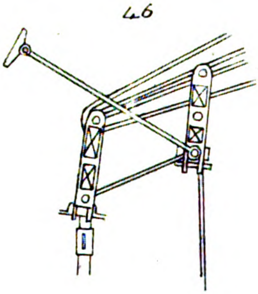

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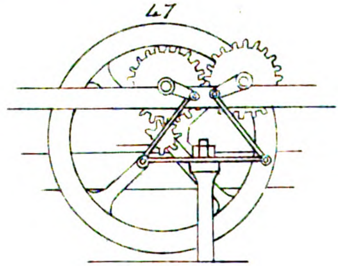

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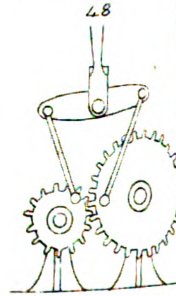

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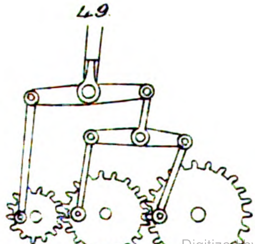

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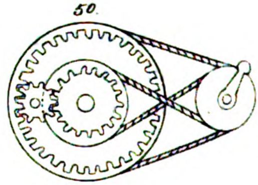

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Figs. 40 and 42 show means of communicating rotary motion to different shafts by endless bands, the speeds of which will vary according to the several diameters of the pullies.

Fig. 41. Cam, the rotary motion in whose shaft produces vertical motion in the upright rod, varying according to the outline of the cam.

Fig. 43, shows how shafts may be driven by bands, although placed at right angles to each other; if driven opposite to direction of arrows, the bands will run off.

Fig. 44. Drilling Machine motion, in which rotary motion is produced in upright drill shaft by bevil wheel, the drill shaft being free to slide through small wheel, but carried round by it. Drill shaft is depressed by connexion with foot-board being attached to the upper lever by a swivel.

Fig. 45. Heart-shaped cam producing a uniform traverse motion in any thing bearing on its periphery. In transferring motion from cam surfaces, levers are usually employed having small rollers bearing on cam, and kept in contact by springs.

Fig. 46, the parrallel motion of ordinary beam engine, the radius rods (one on either side) having joints fixed to frame work, constrain the piston and pump rods to move in a truly vertical direction.

Fig. 47, means of imparting rotary motion to fly-wheel shaft from a piston rod, maintaining at the same time the parallelism of its motion.

Fig. 48, a modification of 47, but in which the rotary motion is maintained without fly-wheel by reason of different diameters of wheels, while one short connecting rod is at the dead point, the other is in full action.

Fig. 49, a further modification of the same of a more complex character.

Fig. 50. Band pulley on the right drives the toothed circles in opposite directions by means of endless bands, the teeth imparting motion to pinion round its own axis, also round the common centre of toothed rings, like the motion of a planet.

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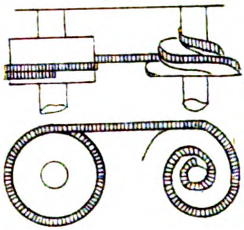

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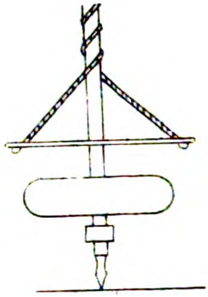

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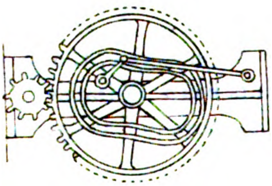

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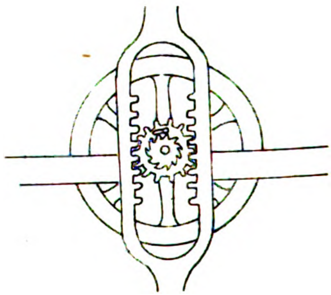

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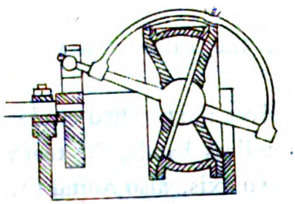

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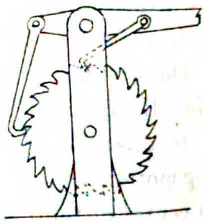

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Fig. 51, the fusee motion of the watch used to counteract the unequal tension of the spring, which is wound up in the the barrel to the right, the chain winding on its exterior; when wound up the chain strains upon the small part of snail or fusee, but as it runs out the chain passes gradually on to the increasing radius, as seen in lower figure.

Fig. 52. Primitive Drilling Apparatus, by alternately pressing down and relieving the cross bar, the cords alternately wind up on spindle in opposite directions, the heavy disc pressing on the drill, and giving momentum to the rotary motion:

Fig. 53, the wheel and cam groove being carried round while the short crank arm is loose on the shaft, an irregular vertical motion will be produced at the joint of radius rod in cam groove.

Fig. 54, two toothed wheels, one behind the other, and loose on the shaft take into opposite racks, toothed wheels have each palls taking into separte ratchet, wheels fixed on the shaft with teeth in opposite directions, upward motion being given to the rack frame, rack on the right will force round shaft by pall and ratchet, while the other wheel runs loose; at the down stroke the opposite action will take place, driving fly-wheel constantly in the same direction.

Fig. 55, cross section of Disc Engine, in which the disc seen in edge view has a motion similar to a coin before it falls, after spinning it on a table; it is placed between two cones right and left, and is sustained and moves on the ball from which the driving arm is projected through the centre of left hand cone, and which gives motion to the crank arm or wheel on end of shaft to the left; the steam is admitted alternately on either side of the disc.

Fig. 56, an oscillatory motion being given to the horizontal lever, the claw-kers alternately take hold of a tooth in the ratchet wheel, and turn it in the same direction.

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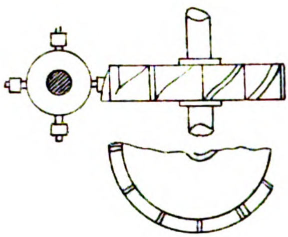

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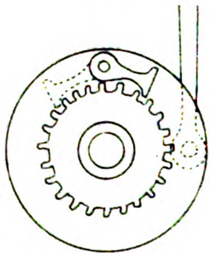

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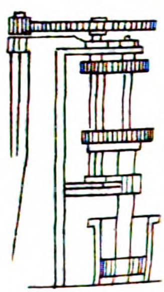

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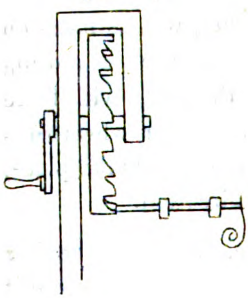

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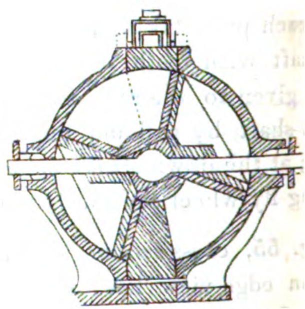

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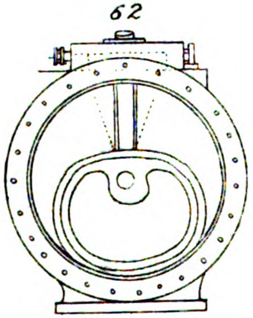

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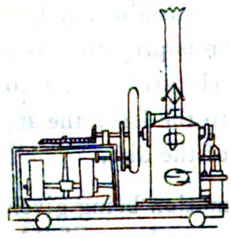

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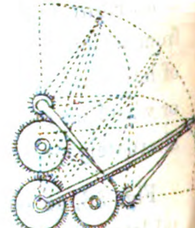

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Fig. 57, rotary motion being given to shaft on the right, the projecting trucks come in contact with the successive inclines on the horizontal wheel on vertical shaft, communicating an intermittent rotative motion thereto.

Fig. 58, a reciprocating motion of the vertical rod gives partial rotary motion to disc loose on shaft, and gives intermittent rotary motion to wheel fixed on shaft in either direction, according to position of pall at upper part.

Fig. 59, Self-acting Vertical Cylinder Boring Machine driven by vertical shaft to the left, the gearing being arranged to regulate the speed, and advance the cutters as the work progresses, all the wheels keeping their proper relative positions.

Fig. 60, driving the wheel gives a rapid lateral traverse of horizontal rod, which is pressed back by a spring ; the teeth of wheel being inclined on one side only, it is obvious it may not be worked in the opposite direction.

Fig. 61, is a section, and Fig. 62 an end view, with one hemisphere removed, of rotatory engine invented by John Wallace Duncan, Esq. consisting of two cones, one on either side of a fixed vertical disc, and enclosed by two hemispheres, the cones are united at upper part by a diaphragm, which passes steam tight through upper part of disc, steam being admitted alternately on either side of disc, is backed up by cross diaphragm, and produces a kind of rolling motion of cones on opposite sides of the disc, and consequently imparts a rotary motion to the horizontal shaft.

Fig. 63, Portable Steam-engine and pair of Edge Runners, for crushing and grinding.

Fig. 64. Instrument invented by the Rev. H. M. Grover, applicable to sextants and other instruments of observation, for finding the measurements of the sines and cosines of the arcs of circles. The long index hand, which describes the quadrant, communicates motion to pointer hands, which describe semicircles in the same time. The distances of the pointers from the centre of index hand indicated on the gra-

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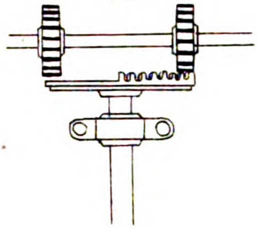

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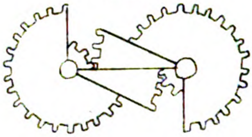

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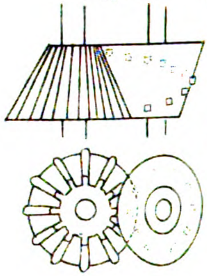

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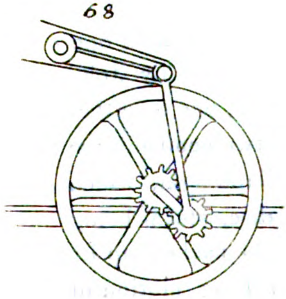

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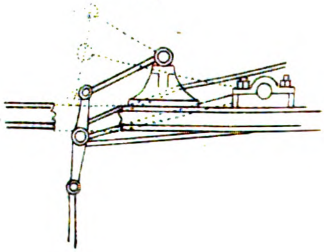

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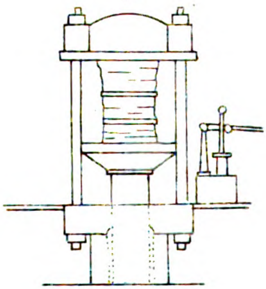

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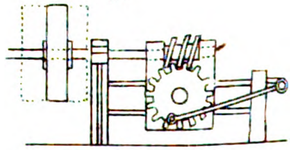

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duated line, will be measures of the sine and cosine of the arc, defined by the position of the long hand.

Fig. 65, continuous rotary motion in vertical shaft imparts alternately rotary motion in horizontal shaft, by the segment of teeth when engaging one wheel, turning the shaft in one direction, but while engaged in the other wheel, turning it in the opposite direction.

Fig. 66, the toothed segments of equal radius transmit equable motion from one shaft to the other, but immediately the segment of larger radius engages with smaller segment, a marked difference in the rate of speed transmitted will take place.

Fig. 67, a modification of 66 arranged in bevil gearing, the one wheel having leaves or teeth, the other being furnished with projecting pins.

Fig. 68. Sun and Planet motion, invented by Watt as a substitute for the crank; one wheel is fixed rigidly to the end of connecting rod, while the other is on main shaft; they are held together by the link; the motion of connecting rod wheel once round, the wheel on shaft causes it to perform two revolutions, aud so gives two revolutions of the main shaft for one up and down stroke of engine.

Fig. 69, modification of parallel motion transmitted from oscillating beam, which will be readily understood by studying the different positions shown.

Fig. 70. Hydraulic Press; water being forced by small pump on the right into the cylinder at bottom, forces up the ram and table supporting materials to be pressed, submits them to enormous pressure between the table and cross head.

Fig. 71, rotary motion given to strap, rigger communicates motion by endless screw to screw wheel; this wheel being controlled by connecting rod, the whole carriage and wheels have a to-and from-motion on guide rods.

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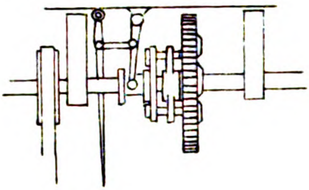

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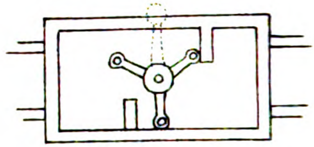

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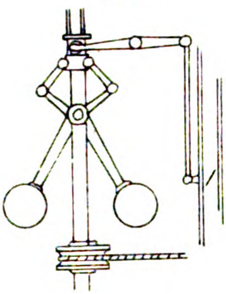

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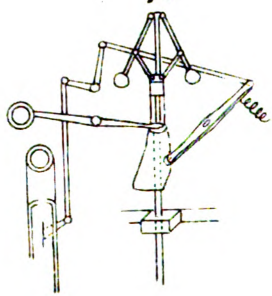

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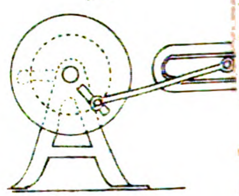

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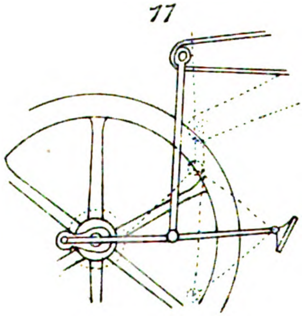

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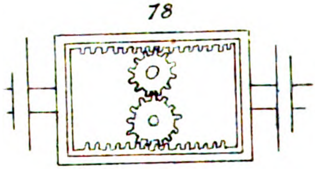

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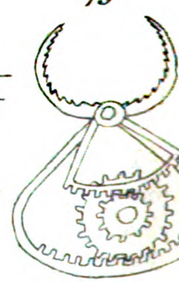

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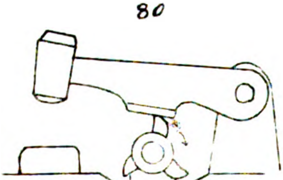

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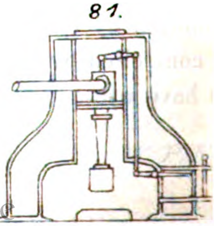

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Fig. 72, toothed wheel being loose on shaft, is engaged by moving lower end of hand lever to the right, which throws the clutch pins into wheel, the opposite motion withdrawing clutch, and so suspending the motion of machinery in connection with such wheel.

Fig. 73, rotary motion given to tappet shaft, gives an alternating traverse motion to rectangular frame.

Fig 74, governor or double pendulum driven by the engine whose motion it governs, the expanding or flying out of the balls, draws down left hand end of horizontal lever, and through it acts on the throttle valve in the steam-pipe on the right and so obstructs the passage of steam to cylinder, when the motion of engine is becoming too fast.

Fig. 75, a modification of Fig. 74, in which the governor takes effect on the throttle valve, by means of an expansive cam raised or lowered by the governor; when raised, it actuates the connecting levers so as to cut off the steam during a great portion of the stroke, and when lowered to permit it full on during the whole time.

Fig. 76, the alternate traverse motions in the guides to the left may be varied by fixing the crank pin in the radial slot of rotating disc, further from or nearer the shaft or centre.

Fig. 77, connection between beam of steam-engine and crank, in which the crank and fly-wheel performs two revolutions for each complete stroke (up and down) of the engine; the joint to the right is a fixed point.

Fig. 78, by rotating one of the pinions, both being on fixed centres, the rectangular frame will have an equal impulse on either side.

Fig. 79, one segment of teeth being fixed to each jaw, by turning the axle of wheels, the jaws will be brought forcibly together.

Fig 80. Tilt Hammer for forging large masses of iron.

Fig. 81. Nasmyth's steam ditto; the cylinder is fixed above, and the hammer suspended to piston rod, which is

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Miscellaneous.
Clark's Table of Mechanical Motions.

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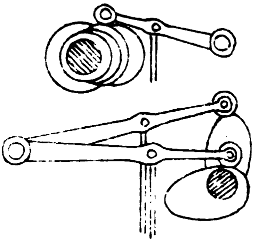

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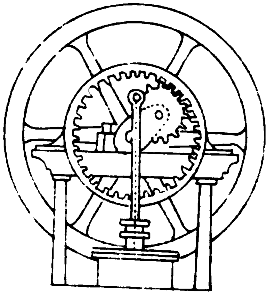

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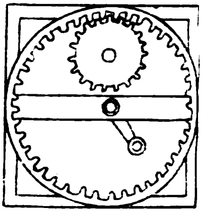

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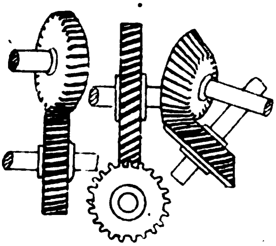

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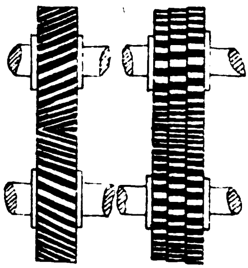

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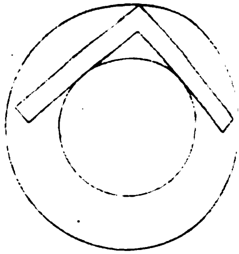

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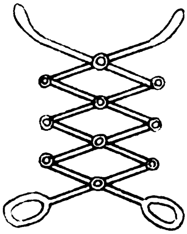

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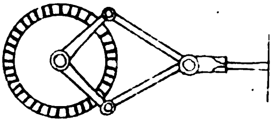

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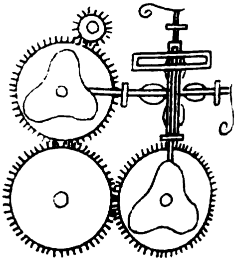

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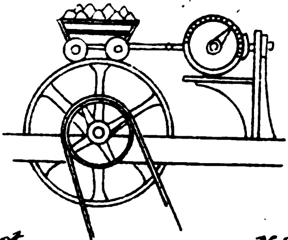

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alternately raised and suffered to fall by admitting steam below the piston and allowing it to escape.

Fig. 82, the lower figure represents cam motions such as used for actuating the valves of steam engines, the black section being a rotating shaft. The upper figure shows a series of cam surfaces for working steam expansively, the steam being cut off at any point of the stroke, according to the cam surface caused to act on the truck or roller.

Figs, 83 and 84, methods of converting rectilinear into circular motion, and *vice versa*; the circular rack being fixed and the pinion of just half its diameter, any point of its circumference will describe a straight line across the diameter of rack, and in 83 is shown as applied to piston rod of an engine, the pinion being mounted on the crank pin.

Fig. 85, arrangements of screw wheels and bevil gear, for varying the direction of shafts and other purposes. Fig. 86, Step and Inclined Tooth Gearing.

Fig. 87, the limbs being placed in contact and moved round the smaller circle, the angle describes the larger circle.

Fig. 88, Lazy Tongs, which extend to great length when closed.

Fig. 89, supposing the rod on the right to have an alternating motion, the face wheel with ratchet teeth will be caused to rotate by means cf one of the radial arms catching the teeth, while the other slips over them, thereby propelling it almost continuously in the same direction.

Fig. 90, the cams on the first and third wheels being driven at an uniform rate, a point in the cross rods participating in the combined action of the two, will describe the figure shown.

Fig. 91, method of testing the friction of loaded and unloaded carriages, by which it is found that the speed once obtained, the friction does not increase with any increase of speed in the great wheel driven by the band, but any ad-

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Miscellaneous.

Clark's Table of Mechanical Motions.

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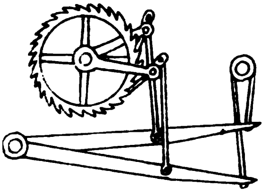

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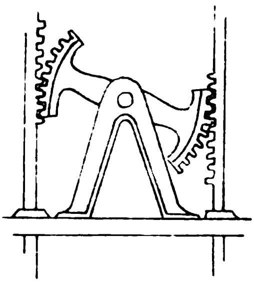

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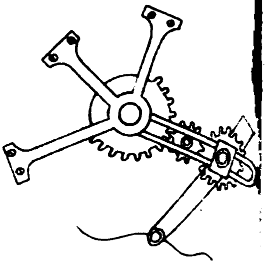

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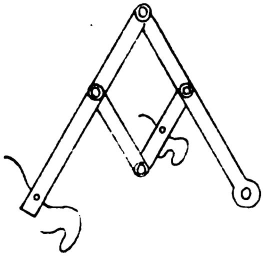

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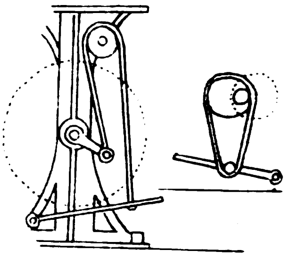

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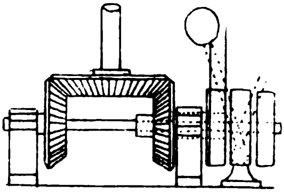

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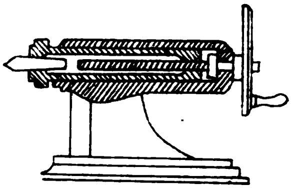

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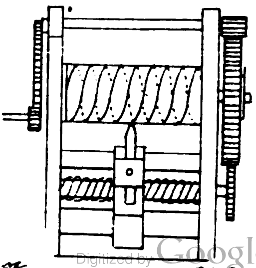

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dition of weight placed in the carriage, immediately causes an increase of tractive force, to be shewn by the indicator on the right.

Fig. 92, Double Treadle Motion, by which continuous rotary motion may be given to the ratchet wheel.

Fig. 93, curvilinear motion converted into a rectilinear for pumping or like purposes

Fig. 94, the slotted arm being moved on the principal centre, with the centre wheel fixed, the pointer of the pointer arm, which is fixed to its wheel, will describe a line curved according to the proportions of the toothed gearing.

Fig. 95, the pentagraph having a fixed pivot on the left, when one pointer is traced over a given line or lines, the other pointer will decribe exactly similar figures on an enlarged or a reduced scale.

Fig. 96, the treadle motion on the right gives rotary motion to the shaft by means of an eccentric fixed thereon, with an endless strap passing over it and a roller below; the figure on the left is simply a crank, with a cord over a pulley.

Fig. 97, the outside pullies are fixed, the one to the hollow shaft of bevil wheel on the right, while the other is fixed to shaft and bevil wheel on the left; the middle pulley is loose. The driving strap being alternately thrown from one outside pulley to the other, communicates a rotary motion to vertical shaft alternately in opposite directions.

Fig. 98, Poppet Head of a lathe; turning the wheel and handle on the left with the central screw, projects or withdraws the cylinder carrying the centre, which is prevented turning by a longitudinal groove and pin taking therein.

Fig. 99, the large cylinder being driven by the wheel gearing and motion communicated therefrom to the traversing screw, moving the slide pointer or cutting tool, a screw will be described or cut on the large cylinder as shown.

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Miscellaneous.

Clark's Table of Mechanical Motions

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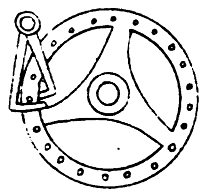

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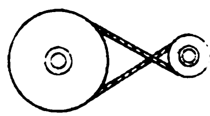

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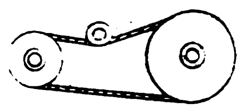

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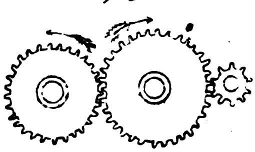

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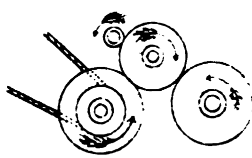

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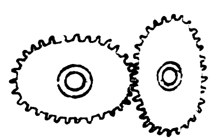

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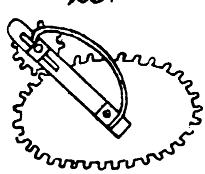

Madras Arty. Depot. N. S W.P.E.

Fig. 100, Form of escapement; oscillating motion of hooked arms to the left, permits pin to escape and wheel to pass round, the next pin is caught on hook of right arm, and on oscillation to the right taking place, it escapes that arm and rests on the other, and is released as before.

Fig. 101, Band Gear with cross belt or band. Fig. 102, Band Gear with tightening pulley to prevent slack. Fig. 103, Toothed Gear. Fig. 104, Friction Gear, in which the different wheels are driven by frictional contact. Fig. 105, Oval Gearing, by which a faster and slower speed is alternately transmitted. Fig. 106 a modification of the above, the pinion being kept up to the wheel by the spring, its axis traversing the slot in the arm.

(Signed) W. Clark, 53, *Chancery Lane.*

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Trajectory of Shells, by Colonel P. Anstruther C. B. Madras Artillery.

Letter from Major (Bt. Col)· P. Anstruther 5th Battalion Artillery, to the Director Artillery Depôt, dated London 2nd June 1857.

Sir,—I have the honor to inform you that I have sent to your address by this day's post, three copies of letters which I have addressed at different times to the Artillery authorities at Woolwich, I will send you their replies when received.

I wish you would print them in the Records of the Regiment with the permission of the Brigadier Commandant, and I beg you to send one copy at once to Lieutenant Colonel Croggan, who will recognize the Trajectory as his own, a fact I was not aware of till lately.

I have to request you will publish this as a preface to these letters, and further that you will try the following experiments for me—Take a 10 inch gun of 9 feet 4 inches, if available, if not, take the longest 8 inch gun procurable. Load with such charge as will throw a shell, run full of lead, exactly 1000 yards at 45°. Then find the ranges at 20°, 25°, 25° 54′, 30°, 35°, 40°, 50°, 55°, 60°, 65°, 70°, 75°, and 80°, taking care that the shell is the same weight, the charge the same weight, the gun and every thing except the elevation the same throughout.

The only important point is to get it done quickly.

This will reach you in the middle of July and these 12 ranges might be got each day during one week between Sunday and Sunday, firing each elevation once every day, using exactly the same powder throughout, we should thus have the most perfect lesson ever taught to the profession.

Letter from Major (Bt. Colonel) P. Anstruther Madras Artillery to Major General Sir Fenwick Williams, of Kars. Bart., K. C. B. Royal Artillery dated 1, *Chapel Street, Grosvenor Place, London, Wednesday* 4*th February* 1857.

Sir,

1. I am very anxious to obtain the opinion of competent professional judges, on a subject to which I have given much attention for many years; and I make this appeal to you, as being in a situation where you may perhaps procure me the opinion I wish for, or show me how to proceed to obtain it, or from whom to ask it.

2. Though the matter is purely professional, it does not appear to me to be one that will be properly within the sphere of the deliberations of the Select Committee of the Royal Regiment of Artillery; it is so wholly a Mathematical Question, that I think so numerous a body as that Committee would hardly discuss this matter.

3. I hope, therefore, that you will nominate, or procure from higher authority the nomination of, a smaller Committee; and I should suggest, if practicable, that Captain Boxer, Royal Artillery, and the Professor of Mathematics at Woolwich Academy, or Addiscombe, or both, should be induced to assist.

4. They would have to decide upon a curve which I proposed some time ago, as a substitute for the Parabolic Curve so largely employed in reasoning upon Projectiles as a Science. My proposal was Printed in a periodical called the *Artillery Records*,* published monthly at Madras, and sold to all purchasers. It was never noticed in the slightest degree, never answered. I believe that by the use of this curve, and the reasoning it leads to, we may give answers to all the questions hitherto considered beyond our reach. For example:—

5. In Douglas's *Naval Gunnery*, 4th Edit. p. 565, we find as follows:—" Elevation being 30°, the range was 4785

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yards." I believe I can demonstrate that from this fact, we can deduce the initial velocity, and that we may lay down with exactness and certainty what would be the range at 35°, 40°, 45°, 50°, 55°, 60°, 65°, 70°, and 75°, with the same charge.

6. I believe this is not found in any of our works on Artillery Science, and some such Committee as I have pointed out, would be required to authorize our teachers of Mathematics, to incorporate this with the lessons they give the rising generation of Artillery Officers.

7. The support of such a Committee would very probably procure me the means of following out a series of very interesting and valuable experiments on vertical fire, which I was about to commence when obliged to leave India.

8. I append to this my letter of date 28th of October, 1855, the concluding phrase of which I would now vary, thus:—I said I was not confident that I could show how to obtain the initial velocity from the range; I can now do so, and that with a degree of accuracy which exceeds that of the Ballistic Pendulum, for $\frac{1}{100}$ of its price.

9. Having given the range at 45°, the initial velocity is the time of flight in seconds, multiplied by $32\frac{1}{6}$, and the product again multiplied by the square root of two, or 1·4142136—, or, T×45·4905375. I always use 45·49 for the multiplier, and hence I get the following calculated velocities for the four last given ranges of Douglas, already quoted.

Elevation.	Range.	Velocity.		Variation.
30°	4785 yds.	1548·952	1552 Average.	—3·15
31°	4765 „	1545·95		—6·15
32°	4860 „	1560·3		+8·3
33°	4795 „	1553·5		+1·5

I offer the four results of the Ballistic Pendulum's trials from page 47 of Colonel Mordecai's invaluable work, which are nearest to these in amount; they are got with 6·4 lbs. of powder, and average 1551 feet velocity. Their variations from the average are +4,—72, +89 and—21.

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10. I will now give the mode of working out only one of the four. the first, to show how very simple the matter is.

Given—At 30° the Range was 4785 yards, or 14,355 feet.

Required—The Initial Velocity.

	Logarithim.
Divide 14,355 by $16\frac{1}{12}$, it is spaces 892·54	2·9506271
Add the Secant of 30° for...	10·0624694
The Hypothenuse ... ...1030·615	3·0130965
Add the Sine of 30°, for	9·69897
The Altitude ... ... 515·365	2·7120665
The Square root of which is the Time 22·734	1·3560325
We calculate to tenths of seconds; therefore,	$n=227$.
The sum of the series is our hypothenuse,	1030·615.

The common difference is 2.

$\frac{E+e}{2}\times n=S$, or $\frac{E+e}{2}\times 227=1030{\cdot}615$ or $\frac{E+e}{2}=454$, or $E+e=908$.

$\frac{E-e}{n-1}=d$, or $\frac{E-e}{226}=2$, or $E-e=454$.

Then if $E+e=908$ and $E-e=454$, then $E=680$.
$c=228$.

Then if E be 680, the time of flight is 340 tenths, or 34 seconds for the time of flight at 45°, and 34×45·49 for the initial velocity, or 1546·66. The table of gradually diminishing addition velocity for 340 tenths of seconds is too long to print: it begins

6·79=6.79
6·77=13·56
6.75=20·31, &c. &c. Thus, at 340 it is 1156·00, the square of 34.

Further explanation I reserve for oral discussion, asking you to excuse my intruding upon you on so very slight an acquaintance as my introduction to you enables me to claim. I print my letter for facility of perusal, and to enable the gentlemen to whom you may refer the question, to think of it beforehand. I will hold myself in readiness whenever you may kindly obtain for me a Committee of competent Judges.

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Trajectory of Shells, communicated by Lieutenant Colonel P. Anstruther, C. B.

From "Madras Artillery Records."*

To the Director Artillery Depot.

Sir,—1. I look upon the Parabolic Theory of Projectiles as a valuable hint as to the real path of a body projected, and I think we might, with a modification of this curve, arrive at something very like the true Trajectory of a Shell.

2. The Parabolic theory is this,—Let A H. (Plate 29) be any horizontal line which I will suppose to be 121, divide this into eleven equal parts, of 11 each, and erect 10 perpendiculars. Draw a line from A at an angle of 45° cutting each of these ten perpendiculars, the length of the perpendiculars will be 11, 22, 33, 44, and so on. From these intersections successively mark off 1, 4, 9, 16, 25, the squares of the times, and join the points, you have the Parabola, the curve of the Projectiles' course, which in our supposed case would range $121 \times 16\frac{1}{12} = 1946\frac{1}{12}$ feet or 648 yards 2 feet 1 inch.

3. But this supposes that the body is projected in free space and with uniform velocity. Now we really have nothing to do with free space and cannot give uniform velocity. But we can lay off, instead of eleven equal spaces of eleven each, the real horizontal range for each second, which is $2t-1$, that is for 11 seconds it is 21, for 10 seconds it is 19, and 21, 19, 17, 15, &c, the sum of which will be 121. At these distances, and not at equal distances, erect your ten perpendiculars and mark off, exactly as before, join the points and you have the Trajectory, not a Parabola, but the true path of the Projectile.

4. I forward two drawings Fig. 1 and Fig. 2 (Plate 29) shewing the Parabolic Curve, and my proposed Trajectory, if you will give them early insertion in the Records, I will prepare some further papers shewing the application to other

* Page 333, Head Miscellaneous.

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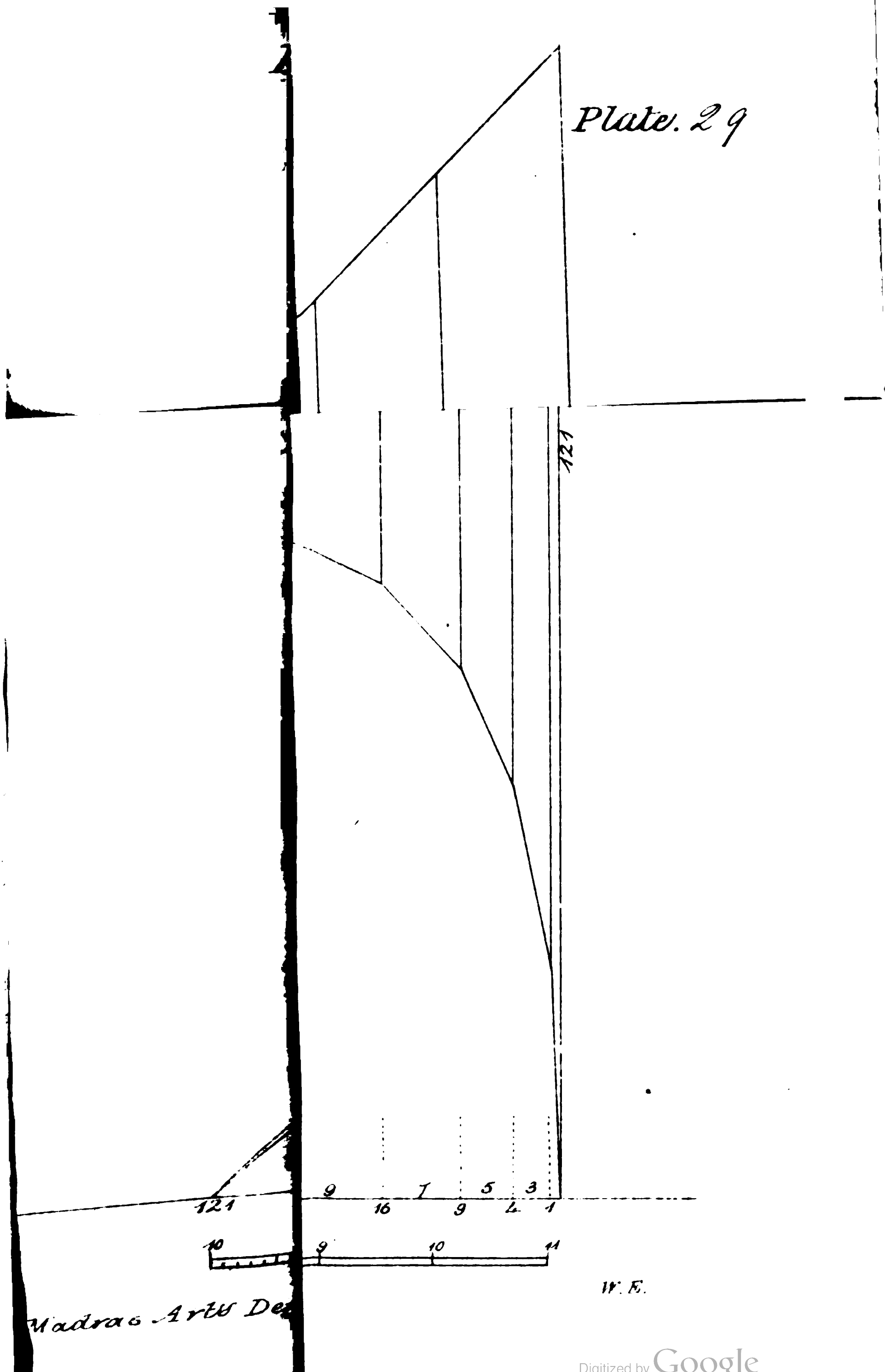
Plate. 29



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angles of elevation, and, I think, I can show how to get the real initial velocity from the range, but of this I am not confident.

Your obedient Servant.

Madras, October 28th, 1855. P. ANSTRUTHER, *Lieut.-Col.*

Letter from Major (Bt. Col.) P. Anstruther Madras Artillery to the President of the Select Committee of the Royal Regiment of Artillery, Woolwich, dated 1 *Chapel Street, Grosvenor Place, London, Tuesday 24th February* 1857.

Sir,—1. I request you will furnish to each of the Members of the Committee, of which you are President, the accompanying paper, containing "Velocities calculated from Ranges," which I am anxious to submit to the Profession at large.

2. I have found that nobody will attend to this sort of question, unless coming backed by the Authority of some such Committee as I attempted to procure, but without success. I have been referred to your Committee, to which I did not intend to apply, until the Professors had pronounced upon the strictly Mathematical part of the question.

3. In any case I must have come to your Committee to obtain the necessary means of carrying out my experiments, but they would certainly give me every support, if they had the sanction of such names, for the more abstruse portion of the subject.

4. I will confine myself at present, to asking the Committee to pronounce an opinion upon the paper of calculations, reserving for their future discussion, the question of giving me support in carrying out my experiments, or, as I should much prefer, carry out themselves the further plans I had sketched out to be worked up, had my health enabled me to remain in India.

5. I will reserve also for a future paper, the question of the results to follow, or the inferences to be drawn from these calculated Velocities, until I see whether the reasoning is admitted to be correct, whether the Trajectory is adopted as a substitute for the Parabolic Curve.

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GIVEN, ÊLEVATION AND RANGE, TO REDUCE THE VELOCITY.

Elevation.	Range, in Yards, given.	TRIANGULATION. Base, given, in spaces of $16\frac{1}{12}$ feet Logarithm.	Log. Base + Log. Secant of Elevation = Hypoth.	Log. Hypoth + Log. Sine of Elevation = Altitude.	Half Log. of Altitude = Logarithm of Time, in Seconds.	Time of Flight in Seconds × 20.	E−e	Hypothenuse divided by Time, and multiplied by 2 = E+e Logarithm	E+e Nat. num.	E	Initial Velocity in Feet per Second.	Charge. lbs.	oz.
35°	5600	3·01893	3·10557	2·86416	1.43208	27·0445	540·891	2·97452	943·015	741·953	1687·6	17	0
,,	437	·00610	·09274	·85153	·42567	26·6481	32·961	·96810	29·190	31·075	62·8	16	0
,,	200	2·98675	·07338	·83198	·41599	26·0608	21·216	·95843	08·712	14·964	26·2	17	0
15°	4001	·87291	2·88797	·30097	·15048	14·1411	282·822	3·03852	1092·740	687·781	1564·4	17	0
,,	3585	·82523	·84029	·25329	·12664	13·3857	67·715	·01463	34·373	51·044	1480·8	7	0
,,	46	·82048	·83554	·24854	·12427	·3127	6·255	·01230	28·731	47·493	72·7	6	0
,,	34	·81901	·83407	·24706	·12353	·2902	5·804	·01157	26·990	46·397	70·2	8	0
,,	13	·81642	·83148	·24448	·12224	·2506	5·013	·01027	23·933	44·483	65·9	8	0
,,	3499	·81469	·82974	·24274	·12137	·2421	4·841	·00940	21·891	43·366	63·3	10	0
,,	69	·81095	·82601	·23900	·11950	·1674	3·349	·00753	17·501	40·425	56·6	10	11
,,	44	·80781	·82286	·23586	·11793	·1199	2·398	·00596	13·828	38·113	51·4	10	0
,,	3391	·80107	·81613	·22913	·11456	·0176	0·353	·00260	05·997	33·195	40·2	7	0
,,	59	·79696	·81201	·22501	·11250	12·9569	259·139	·00054	01·238	30·188	33·4	12	0
,,	3284	·78715	·80220	·21529	·10760	·8115	6·230	2·99563	989·998	23·114	17·3	8	0
,,	3193	·77494	·79000	·20300	·10150	·6327	2·655	·98953	76·185	14·420	1397·5	5	0
,,	52	·76933	·78349	·19738	·09869	·5014	1·028	·98673	69·897	10·462	88.5	4	0

N. B.—The Ranges and Elevations are taken from the Appendix to *Douglas's Naval Gunnery*. The calculations are offered for consideration.

P. ANSTRUTHER, *Colonel.*

P. S.—E—e, and E+e being obtained $E \times \frac{g}{2}\sqrt{2} = E \times 16\frac{1}{12}\sqrt{2} = E \times 45{\cdot}49 = V =$ the Velocity.

Letter from Major (Bt. Colonel) P. Anstruther to the President of the Select Committee of the Royal Regiment of Artillery, Woolwich, dated 1 *Chapel Street, Grosvenor Place, London, 20th April* 1857.

Sir,—1. I have the honor to request that you will furnish to each of the Committee, of which you are President, a copy of this letter, in continuation of my letter of date February 24th.

2. The following is the theory on which I calculate the flight of projectiles.

3. A ball projected at an upwards angle is acted upon by three distinct forces, namely—

1st. Impetus, urging it.

2nd. Gravity, deflecting it.

3rd. Resistance, stopping it.

4. Combining the first and second of these, we have the Parabolic Theory, which ignores the third force. But the Parabolic Theory is not practically true, the third force should not be ignored.

5. By combininig the first and third, and modifying the result by the second, we should have a practically useful Trajectory, such as I offered to the profession at large on the 28th October, 1855.

6. The first and third of these three forces are directly opposed to each other; the result is, that sooner or later the resistance of the atmosphere overcomes the impetus, and the ball, if undeflected by gravity, unattracted by the earth, would stop up aloft, but vertically over that exact spot which it now reaches by gravitation, combined with the result of the two opposing forces, the first and third. Gravity does bring it down to the ground.

7. It will be convenient to fix a time of flight, and to use the angle of elevation 45° to begin with, say eleven seconds time of flight, Then the initial velocity of a ball

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which ranges during eleven seconds at 45° is $11 \times 32\frac{1}{6} \times \sqrt{2}=$ 500·3959125. That cost me much trouble to fix; I have since learned that it is perfectly well known and admitted as fact at Cambridge. It is to be regretted that more publicity is not given to the information possessed by the schoolmen.

8. The first thing is to graduate the hypothenuse.

The base is 121 spaces of $16\frac{1}{12}$ feet. Divide this into eleven portions—21, 19, 17, 15, 13, 11, 9, 7, 5, 3, 1. Total 121.

Erect perpendiculars at these distances and draw your hypothenuse at an angle of 45° with your base.

Then the distances from the muzzle will be, on the horizontal line or base, 21, 40, 57, 72, 85, 96, 105, 112, 117, 120, and 121.

And the distances on the hypothenuse will be these, multiplied by the square root of 2.

And for any other angle of elevation, greater or less than 45°, the hypothenuse remains the same; the range and the altitude will differ, but the hypothenuse remains the same unless gravity shortens it.

Now any portion of the hypothenuse is obtained thus—Suppose you wish to know the range for 8·4 seconds time of flight. Deduct 8·4 from 11, the hypothenuse of greatest possible time, it leaves 2·6. From the square of 11 take the square of 2·6, (121—6·76) you have 114·24. Then is the length of the hypothenuse $114{\cdot}24\sqrt{2}$, and the square of the time is the perpendicular. The square of the perpendicular subtracted from the square of the hypothenuse is the square of the range, that is $(114{\cdot}24\sqrt{2})^2 - 70{\cdot}56^2 = 26101{\cdot}5552 -$ $4978{\cdot}7136 = 21122{\cdot}8416$, the square root of which is 145·337 spaces of $16\frac{1}{12}$ feet, or 2337·5 feet, or 779 yds. Then, as $114{\cdot}24\sqrt{2}$: 90° :: perpendicular (70·56) : 9·6402254 which is the sine of 25° 53′ and odd seconds, very near 25° 54′.

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9. Now I find that, the velocity remaining as before, the range for

8·39 seconds is $\sqrt{21122{\cdot}70527041}$ in spaces of $16\frac{1}{12}$.

8·4 „ „ $\sqrt{21122{\cdot}8416}$ „ „

8·41 „ „ $\sqrt{21122{\cdot}81268161}$ „ „

showing that the range for 8·40 seconds is longer than that for 8·39 and a little longer than that for 8·41.

Therefore 8·4 is the longest range attainable with this velocity, and 25° 53′, odd seconds, is the elevation for greatest range always. With double this velocity, a shell would have in double the time, 4 times the range, or 3116 yards range with 1000 feet velocity; 3 times the velocity would have 3 times the length of flight, or 33 seconds time of flight and 9 times the range, or, for 1500 feet velocity, 7011 yards, or 4 miles range.

10. And this I beg to recommend we should try at once: does or does not elevation of 25° 53′ give maximum range to a shot or shell?

11. To try this, two logs of timber laid alongside to receive the trunnions, and a trench dug to give play to the breech, would enable us to use such a bed for vertical fire as we built at St. Thomas's Mount some years ago, and we might use a 10-inch gun, with shell run full of quicksilver so as to ensure the greatest accuracy.

Letter from Major (Bt. Colonel) P. Anstruther Madras Artillery to Colonel Pickering, Royal Artillery, Woolwich, dated 1 *Chapel Street, Grosvenor Place, London,* 1*st May* 1857.

Sir,—1. I have the honor to acknowledge the receipt of your letter of date 24th April, and to request that you will ask the Select Committee of the Royal Regiment to obtain for me the sanction of the Secretary of State for War for trying, at my expense, the experiments necessary to establish the truth of my Theory of Projectiles.

2. For this purpose, I would select a 10-inch gun of 9

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feet 4 inches length, and fire shells run full of lead, or of quicksilver, at all elevations from 20° to 80°, with such charges as the length of the range ground may permit. I propose to lay the trunnions on two of the largest logs I can procure laid on the ground, or on logs transversely placed. A small trench 4 or 5 feet deep would give play to the breech, and the expense would be very trifling.

3. The kindness of a distinguished Cambridge mathematician enables me to substitute for the tedious process of my letter of date February 4, the following:—

Given, the range—To find the time of flight at given angle.—Multiply range in spaces of $16\frac{1}{12}$ by tangent of angle.

		Logarithm.
Ex. gr.	Range in my example was 892·54 spaces........................	2·9506271
	Tangent of 30°........................	9·7614394
	Altitude of Triangle..................	2·7120665
Sq : root of which is, Time 22·7............		1·35603325

exactly the same as I gave it, but more neatly.

4. He pronounces me to be right so far that at 45° we get $V = Tg\sqrt{2}$. But he applies this to Hutton's old formula for any angle, $T = \frac{SV}{\frac{1}{2}g}$, and I do not think this applies except to the angle of 45°.

5. He declares his adherence to Hutton's old rule, viz. the range for any angle is thus found: As sine of double a given elevation to its range, so is sine of double this elevation to the range required. And he particularizes 35° thus: The range at 30° being 4785 yards, then at 35° it will be $4785 \times \frac{\sin. 70°}{\sin. 60°}$. Here we join issue. Will the range be so? I say it will be very considerably less than 4785 yards; by Hutton's old rule it should be 5192, or 400 yards more.

6. I am not able to argue against such odds; my long service has thrown me out of all chance in mathematics, but

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I will trust to the gunpowder which never yet deceived a gunner. For this purpose however, I will not trust a hollow light projectile thrown from a short inaccurate piece, at such angle as to come down wildly irregular, but I will use the heaviest projectile I can, thrown at the highest elevation practicable, from the longest piece procurable, with the largest charge I think safe and I will believe in the results.

7. And I beg you will do me the favour to obtain for me, the means of doing this, without waiting for the result of the trials which, I can confidently answer for it, will be carried on at St. Thomas's Mount, but of which I cannot learn the results till another season is lost.

On Boxer's Fuzes &. Shells by Capt. C. D. Waddell Madras Arty.

According to the very interesting Papers published in the records for February last, contributed by Captain Hutchinson, it appears that Captain Boxer's Fuzes have been thought so highly of, as to cause their being substituted for the ordinary fuzes, in the Royal Artillery.

The having fixed fuzes to which Fuze holes shall be made, is the first and greatest step to having good Fuzes, and having fixed sizes for the Fuzes necessarily follows, requiring a more exact manufacture of them in the lathe, than at present obtains.

Boxer's Fuze starts with these essential conditions in the first construction of the Fuze, and thus does away with the necessity for all the rasping and fitting which are the bane of the present Fuze, and so much detract from its usefulness.

The Authorities at home appear to fully appreciate the importance of introducing this uniformity in Fuze holes and fuzes, and it is greatly to be wished that a like reform was introduced with us.

In comparison with this point gained in Boxer's Fuze, nearly all the others are of minor importance, although the numerous borings and channels are great alterations from the

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common Fuze and are the chief characteristics of this, yet the expedient of making so many perforations into the Wood of the Fuze is a bad one, when any other efficient means of attaining the object in view, are possible.

Supposing accurately bored Fuze holes and turned Fuzes, to fit without rasping for both, what will be the difference between the time and trouble required to set a common Fuze and one of Boxer's ?

In the latter, the Fuze has to be adjusted in a kind of hooked support in so accurate a position that a bit when advanced by the turning of a screw, may enter with exact concentricity a certain hole in part previously made but now stopped with composition, bore out this composition and continue the boring through a portion of fresh wood into the centre of the Fuze composition.

In the former, the Fuze is fixed in a vice and cut with a saw at the required tenth ring.

Manifestly this is both an easier and simpler operation than the other, which requires more time and more delicate manipulation.

Although so much more work has been bestowed on Boxer's Fuze in the original manufacture, its after preparation for the distances in the Field is not therefore rendered simpler and more rapid, than that of simply cutting off the extra tenths with the saw, *where rasping is abolished for both.*

There is no doubt however that this instrument for boring the side holes, ensures the Bit's entering with some accuracy and in a manner self guided, the hole required to be rebored and continuing the hole with equal precision as to its direction, so far more certainly opening the communication with the Fuze composition, at the exact point desired, than could be done with the saw un-aided by mechanical contrivances as in the ordinary way: But the regulating of the progression and revolution of the Bit by the *one* motion of the screw, is open to great objection ; as long as the Bit is

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well up to and above a certain sharpness, all would go well, but let its edge be more and more taken off by a little use, and a point will soon be arrived at, where the compelled advancement and revolution of the Bit, in this fixed ratio to each other, will cause it to crush before it can cut out the stuff before it, being, perhaps, itself broken by the strain.

The getting through the pressed powder in the side borings and across the fine powder channel would not be the difficulty. But the thin partition of wood, would require to be very lightly and cleanly bored out, to avoid any jamming or splitting of it.

No doubt the remedy is to keep the bit very sharp, and make it of the best of steel, but practically, tools are in general only sharpened when they are found to be blunt, and the knowledge of the fact that the tool was blunt would most likely be arrived at through the premature bursting of a shell, the breaking of the Bit, or the spoiling of a Fuze.

Boring is almost invariably regulated by pressure applied on, and a revolution given to the Bit, which can each be varied independently of the other, to suit the different resistances of materials and the cutting power of the tool used.

The only exception to this that I know of, is, Shanks' Differential screw drill (see Holtzapffel's Work on Mechanical Manipulation Vol. II p. 562.) in which, although the advancement of the Bit depends on the motion that makes it revolve, it is not effected by the *direct* action of a single screw, but by a much more complex arrangement, in this the Bit only progresses the 56th part of an inch in the whole turn of the screw, whereas Boxer's appears to progress nearly the 14th of an inch to the turn, and much too rapidly for the safety of the wood : to proportion the two to each other so as to ensure a safe and clean boring of the Wood by Boxer's instrument, would require his screw to be of a much lower pitch, and therefore much finer threads, which would be quite

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inapplicable to a tool constantly requiring screwing and unscrewing, while subjected to the strain of the boring.

The arrangements in Boxer's Fuze, for the ensuring its more certain ignition by the firing charge, and that of the bursting charge of the shell, by the fuze are great steps in in the right directi on, and the principles of them could with facility be applied to the ordinary Fuze, with but slight extra trouble or expense attending the alterations.

In the Cup of this fuze, he aims at the better exposure of its contents to the flame of the discharge, the securing them more firmly in their position, and the more thoroughly ensuring their firing the Fuze composition. I do not know whether the Diagrams of his Fuzes as set in the Records, are to scale, but the high shoulder left in setting his Fuze, is most objectionable; the action of such a projection in the air in flight and the way it subjects the Fuze to injury and even extinction by a graze has always been admitted.

After all it becomes a question, when accurate Fuze-holes and fitting fuzes are introduced, why any shoulder should be left at all. I believe a certain portion of the heads of Fuzes is habitually allowed to be left above the surface of the shell on setting, simply because, if much wood has to be rasped off to make it fit (as with irregular sized Fuze holes is often the case) a shoulder is obliged to be left so as not to weaken the Cup of the Fuze, and this shoulder of course checks the Fuze from going in any farther, but when this rasping is abolished there is nothing to prevent the fuze from being set flush.

With the ordinary Fuze, a portion of the head left above the surface is certainly convenient in many ways, it leaves a means of drawing by the fuze Engine, if it has split in driving or has been driven before sufficiently rasped, but with the accurate Fuze holes and Fuzes, there would be no such a thing as a fuze being set badly, nor a necessity for drawing it.

This projection of the fuze seems to be made quite a han-

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dle of in loading, and is even directed in the exercise for loading a 10 Inch Howitzer, to be seized with the Pincers, as a purchase to guide the shell into the bore correctly, and in loading generally, the hollow rammer-head is placed over the Fuze, and the projection catching in the hollow is made materially to assist the correct insertion of the shell, but this is hardly a legitimate strain to put on it when collars and grummets ought to suffice: Boxer's Fuze heads could hardly stand being made such a purchase of, there would be great risk of the quich match tied round the head, being deranged or rubbed off, and although the hold it has in the hole is sufficient to retain it firmly there, yet it cannot be so tightly in, as an ordinary well set Fuze which is driven with some force with mallet and setter; in grazing, his Fuze might possibly be driven further in, thus damaging the whole interior economy of the shell, if not smashing the Fuze at the same time. Therefore on the whole, it certainly would appear better, with these new Fuze hole and Fuze arrangements to drive the Fuze flush at once. This would necessitate a different arrangement for the insertion of the quick match and priming to that of Boxer's.

At page 29 of the Paper on this subject in the Records, we find it *proposed* that all time Fuzes should have ·2 of an inch bored into the head of the composition; again at page 31 it is *suggested*, that they shall be bored *not less than* ·2 of an inch. Boxer's having this equally indefinitely determined as *about* ·4 of an inch.

No latitude should be allowed in the depth of this hole, the bottom of it being situated most accurately in connection with the side boring, is the main point in the perfect construction of the Fuze, for it is the datum from which its graduation must start, but from the description of the turning of the Fuze, one is by no means satisfied as to whether this datum is fixed with a corresponding amount of mathematical accuracy to that bestowed on the other borings; in fact the

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driving of the Fuze, upon which the boring of this hole must follow, is not mentioned, it however distinctly requires to be done in the lathe with the greatest care, to give real value to the rest of the construction.

This boring is no doubt a very important novelty, and if really of such use, might easily be applied to the present Fuzes, by allowing so many tenths for it extra in the cutting of the Fuze to length, it is not recommended to make this boring on setting the fuze, but on its first manufacture, the efficacy of it, therefore, is not to be sought for in the freshness of the surface of the composition exposed by the boring as might be supposed; it may be observed, that there is more surface of the composition exposed to ignition by this boring than is offered by the mere end of the composition, but in the ordinary Fuze, reliance is placed on the ignition of the match and priming in the first instance, which are supposed then to pass on the fire to the head of the composition by actual contact with it, now it will be found by Boxer's plan only about half the surface of the end of the composition is left in actual contact with the match and priming, by making this boring than there would be if it was not made.

It is very possible that the Fuze composition may more readily ignite with the portion of its upper surface in actual contact with the priming, and with both compositions thus exposed in the side surface formed by this boring, to the air contained in it, an opening is made by it through all, and it forms a recess for a little air to be contained in, close to the point where ignition is required to be fostered.

The action of the inflamed charge in a piece vomiting flame and gases past the shell, on all sides, while momentarily in the bore, must bring about ignition in the Fuze, under very different circumstances to those under which it would be lighted, when unset and by a match, which is the only way we can observe it, indeed, while the flame of the immediate discharge when it encounters the match and priming,

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will no doubt ignite them, it is doubtful whether the gases generated in the combustion, viz. Carbonic Acid and Nitrogen, both not only non-supporters of combustion, but positive extinguishers of flame, may not act with the very contrary effect, and when from the length of the piece the shell is longer under their influence, even tend occasionally to put out the fuze in its early state of ignition, or entirely prevent it from lighting. The period however during which the fuze is exposed to their influence is so extremely instantaneous that it seems hardly possible that it would be sufficient for their bad effects to tell on the lighting of the fuze, ere it was clear of the piece, but this may equally be said on the side of the inconceivability of the fuze's taking fire by so short an exposure to flame.

The products of the ignition of one part of gun-powder are;

Gaseous,	Carbonic Acid.......	=·4885
	Nitrogen.............	=·1043
Solid,	Sulphuret Potassium	=·4072

With the ordinary fuze, all air to feed flame is most probably quite expelled from its vicinity, in the discharge of the piece, so that there seems to be nothing available to support the incipient ignition of the fuze, but every thing to hinder it. A little air close at hand at this time, may therefore be highly favourable to the permanent establishment of ignition; the air contained in the boring at the head of the composition in Boxer's Fuze, would not probably be expelled with the rest in the bore, being in such a recess, the gases would pass by it, and their enveloping the shell would most likely cause the air in the boring to remain fast where it was, and thus afford the desired extra nourishment to the fuze, for the instant.

The products of the ignition of 1 part of fuze composition are not so simple, or so easily determined as for gun powder, but they may be stated as;

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Gaseous.	Carbonic Acid......	=·01661.
	Nitric Oxide.............	=·27403.
	Sulphurous Acid.........	=·12629.
	Oxygen	=·01001.
Solid	Peroxide Potassium....	=·57306.

So that here also, with the exception of the very minute quantity of Oxygen evolved uncombined, all the Gaseous products are Fire extinguishers.

Once a fuze has fairly lighted, no such assistance with Air or Oxygen would in any way be necessary to it, the strong jet of the gases named above, and the Peroxide of Potassium in a state of minute division, issuing from the bore of the fuze with the force that it does, effectually prevents anything having access to the point where the composition is burning; it is this property in the fuze (and the Portfire also) which is its great defence against both wind and water, and makes it appear to burn with such pertinacity; what I have said above therefore only applies to the *very first instant* of the process of ignition of a fuze.

Now as to Boxer's arrangements for ensuring the firing of the bursting charge of the shell by the fuze composition; the custom with ordinary fuzes is when they are cut to an inch and upwards, to provide no intermediate means of communication between the end of the fuze composition and the bursting powder, and when tenths are bored out of the fuze cut to the inch, to stuff up a piece of quick match into the boring; the consideration of this part of the subject has to do with the expiring phaze of the fuzes ignited existence; as a fuze consumes down to the end, it burns more feebly, and the better the fuze, the closer it will burn to the end, before the fire of the very small quantity of remaining composition penetrates to the other side of it; a few minute sparks and particles of melted sulphur and nitre remaining unconsumed, are all that it yields, these become detached from the fuze without an impetus being given them in any

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particular direction; but to make it certain that these last embers of the fuze shall communicate ignition to the charge, they should have some decided impulse given them towards it; the powder channel in Boxer's fuze (besides serving its purpose in connection with the side borings) effects this, its contents are exploded by the sparks of the dying fuze and fire is shot, as it were, into the charge.

The powder cylinder for shrapnell, is a very great improvement on the present way of jumbling the powder and balls together; unfortunately it obliges an extra hole to be bored in the shell to admit the balls and resin, for the cylinder could not be introduced with the balls in, even if fewer were put in to allow for it, on account of the whole weight of the balls tending to the centre and preventing a way being made for it. A hole, too, being made in the side of the cylinder to let in the balls, would be so near the centre of the shell that it would be next to impossible to get them in by it, so that there appears no other alternative left but to make this hole, tap it, and close it with a metal plug; to lessen the number of premature explosions is a great object gained by this plan.

The metallic cup to preserve the heads of the fuzes I rather suspect would not be valued out here.

The diaphram is a great refinement, it must be a troublesome matter to fix it, in fact it is a puzzle to find out how this is done, putting the powder all on one side of the balls is defective and found to prevent a good spread of them on bursting, and this further necessitates grooves being made in the interior on casting the shell, to determine the bursting of the shell in Cloves and the uniform freeing of the balls. The cylinder plan is far the simplest of the two, and apparently good enough for most purposes.

On Lieutenant Gloag's Fuzes.

The November number of the Records, I have just receiv-

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ed and would add a few remarks on the "Advantages" Lieut. Gloag enumerates for his fuzes.

Advantages.

No. 1. Exists no doubt, not omitting the screw driver, and rough imitation of a die-stock.

No. 2. Does not clearly appear, as to the sawing required, for give a wood fuze the advantage of the bouch and you dispense with the rasping.

No. 3. This resolves itself into the questionable advantage of carrying the fuze screwed into the shells in the Ammunition Boxes, instead of separately, the advantage of rapid setting being taken credit for in No. 2.

No. 4. The solid head and washer of fuze No. XV. no doubt answer thoroughly to seal the whole contents of the fuze, thus rendering it safe to carry, but it cannot in that state be said to be ready prepared for use, as with the solid head unscrewed the same conditions which make it so perfectly safe, would as perfectly prevent its ignition, *until* it was decapitated, thus still ultimately requiring the sawing, before it could be said to be "prepared in every respect;" and as to No. XVI, the bursting powder is safe, but the fuze head, beyond having the strong cap hinted at, though not explained, is, as unprotected as any other fuze with the same cap, and it would be little satisfaction to feel, with any fuze on fire in a limber, that the bursting powder could not ignite, with all the other combustibles around it.

No. 5. It is by no means to be taken for granted, that the cast zinc bouch could be driven into the fuze hole fire-tight; such joints between metals, cannot be secured with the rough surfaces produced by casting, but require boring and turning: to thoroughly plug a rough fuze hole with cast zinc would seem to require a great force; these plugs cast to one size, would require one size of fuze hole, as cast zinc is not compressible but very brittle, and by no means so capable

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of being forced into a hole unsuited to it, as brass, or even wood, and this zinc plug is restricted to one place only where it is supposed to fit the fuze hole: practically, many gradations of sized plugs, would have to be cast with a mould for each, and a fuze hole be fitted by a choice among the plugs of that best adapted to drive to the place it should occupy. This in the end would entail as much trouble as tapping each fuze hole and screwing in a bouch, the latter being the more secure method of the two.

No. 6. It is probable that a greater number of these fuzes, could be cast, in a given time, than wooden fuzes turned, and by a less skilled workman.

No. 7. This is a wide question to determine off hand; nothing in this country is exempt from the destructive influence of moisture, and the action of the ingredients of the composition on metals, has always constituted a strong objection to metal fuzes.

No. 8. For practice fuzes this applies, but the advantage of recovering the empty fuzes, arises from the disadvantage of their expensive nature, as compared with wood fuzes, which for their intrinsic value are not worth recovering.

No. 9. This depends on the same disadvantages as the last.

No. 10.⎫ The advantages of a flush fuze I have already
No. 11.⎭ referred to.

The arrangements for the priming and match, in the cups of these fuzes and in their bottoms, are altogether defective. In Fig. XIII, the priming has to be put on after the fuze is screwed in, and the match could not be added so as, *so conveniently* to touch the fuze composition as it is made to do in the Plate, until after the sawing of the fuze to length, or indeed under any circumstances till after the use of the saw, or it would cut the match off: and the unconnected way the priming lies, as to the composition, must make first ignition very uncertain.

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In Fig. XVI. The fuze cup would more securely hold the match and priming.

In Fig. XIV. The "gently twisting" of the match coming from the side grooves over the cut end of the fuze, appears a very uncertain way of ensuring the ignition of starting or bursting powder; and how the match in the side grooves is retained there, and yet capable of being drawn up and down, is a mystery; for by the casting for the grooves, they have no natural tendency to embrace the match, nor is quick match gifted with the property of remaining unsupported in such a groove. These observations are corroborated by the trial of this fuze.

When it is considered that the aim now a days, is to ensure the more accurate cutting of the fuze to length than was attained by the sawing of even the smooth turned wood fuze, it will be at once apparent that the sawing of these metal fuzes, *across the screw thread*, must be a still more inaccurate proceeding, and there is a point in this that must have been quite overlooked by the inventor, that the jarring action of the saw on this screw, unless it fitted very exactly and stifly indeed (which is not very likely to be uniformly the case with cast screws; and not found to answer, see page 588 "unless it is very loose"), would cause it to turn either outwards, or inwards, and the point in the thread at which it was intended to be cut, would more or less imperceptibly be lost sight of; besides, although one turn of the screw would indicate a tenth, yet, as an index of the length of composition, it would only do so, at a point in each thread on that side of the screw, where the helix passed exactly over the lower end of the fuze composition: the result of the trial of this fuze, shews this exactly.

It is also doubtful whether fire might not pass between the male and female screws in this fuze, as it has not the advantage of screwing home to a shoulder, and the female screw contains only 3 or 4 threads.

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The screws as represented in the Plates are all impossible screws, having the ridge on one side running into the groove on the other.

It is not explained whether the zinc plug is cast with the female thread in it, and not shewn in the plate, and there is some confusion, as to the "Composition red" in the Plate; these latter are probably Lithographer's Devils.*

Flight of Projectiles by P. Anstruther, Colonel, Lieut- Colonel of Madras Artillery-

MY DEAR ROWLANDSON,

I had hoped to send you a number of copies of the accompanying pamphlet, by this post, but the very vexatious delays which result from my printers living at Kelso, 8 miles off, has hindered me, I now send only two copies, one for your Office and one for the Brigadier Commandant.—I wish you would set to work at once, and verify or disprove my theory by experiment, it is not right that I should not receive some assistance from my own Regiment.—If you will find what charge does throw any shot or shell 1038 yards at 45°, I suppose every other range in my Table E. page 14 would exactly follow, with the decimal place shifted *one* to the left; that is, the range would be one tenth of what I have given.

Ever yours,

(Signed) P. ANSTRUTHER.

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* Fig. 7 shews that the zinc plug is cast without the female screw; the word "red" after "composition" agrees with the coloring of the original plan furnished; in which the priming and powder in Figs. 4, 5, 6, 13, 15 and 16 are colored brown, but called in Lieut. Gloag's paper "red" which led to the confusion.

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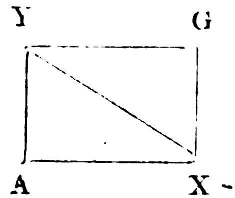

ARGUMENT.

1. A ball in falling from Y to A acquires velocity V.
2. With that velocity V fire a ball upwards, it will go half as far as Y, returning by gravity to A, in the same time as it took to fall from Y to A.
3. Without allowing for gravity, it would have gone to Y.
4. Fire another ball vertically upwards, with velocity equal to V, which would take it to Y, and with equal velocity in a horizontal direction AX, then $AX = AY$.
5. Draw the parallelogram of the two forces, in this case a rectangle, and as the sides are equal, a square; then the two equal forces combine to give the ball motion in direction G, and $AG = AX\sqrt{2} = AY\sqrt{2}$.
6. And the velocity of the two combined is $V\sqrt{2}$.
7. With this velocity $V\sqrt{2}$, fire at any angle greater than 45°. Then the range AX will be less than at 45; the time of flight, which is the square root of GX, longer. The range is the sine of the angle you gave, the time of flight is the square root of the cosine.
8. To find the range for any angle less than 45, graduate AG for time, and mark off the well known graduation of GX for time. Then for any angle the two sides AG and GX being given, the difference of their squares gives the square of AX the range.

P. ANSTRUTHER, Colonel,
Edinburgh, *Oct.* 30, 1857. *Madras Artillery.*

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1. Let the letter S denote the space $16\frac{1}{12}$ feet, then, by the law of gravity, if a ball fall vertically from Y to A in 6 seconds of time, it will fall through spaces, and acquire velocity, as follows:—

In seconds of time,	1	2	3	4	5	6
falling through	$S \times 1^2$	2^2	3^2	4^2	5^2	6^2
that is, through	$S \times 1$	4	9	16	25	36
in each second through	$S \times 1$	3	5	7	9	11
it acquires velocity	$S \times 2$	4	6	8	10	12
the final velocity being 12 S and YA=36 S.						

2. With initial velocity 12 S, fire the same ball vertically upwards. If unopposed, it would travel in 6 seconds through $6 \times 12\ S = 72\ S$. But it is opposed by, 1st, gravity; and, 2d, the resistance of the atmosphere. By experiment we know that a ball fired with this velocity, 12 S, will in 6 seconds of time return to the spot from whence it rose. We see the ball ascend and descend, and we know from par. 1, that in 6 seconds it will descend through 36 S in 6 seconds. We may conclude that, excluding gravity, it would ascend 36 S in 6 seconds, and hence we have the measure of the resistance of the atmosphere—the ascent which should have been 72 S is only 36 S, and there is at the same time a descent by gravity, as shewn in par. 1.

3. We may therefore consider the ball as rising and falling during 6 seconds of time, in the following manner:—

In seconds of time,	1	2	3	4	5	6
with upwards velocity,	$S \times 12$	10	8	6	4	2
rising through	$S \times 11$	9	7	5	3	1
falling through	$S \times 1$	3	5	7	9	11
gaining	$S \times 10$	6	2	2	6	10
it reaches	$S \times 10$	16	18	16	10	0
returning whence it rose in 6 seconds.						

4. Now, suppose that at the exact moment of time you gave the upwards velocity 12 S in the direction AY, you were to give exactly equal horizontal velocity in the direction of AX, then, by the well-known law of statics, these two equal forces, at right angles to each other, will have their resultant, or equivalent, represented in magnitude and direc-

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tion by the diagonal of the parallelogram constructed on the lines which represent the given forces. In this case the forces being equal, and the angle a right angle, the parallelogram is a square, and the diagonal is $AG = AX\sqrt{2} = AY\sqrt{2}$, and the velocity is $12\,S\sqrt{2}$.

5. If we now substitute this diagonal force for the third line of the little table in par. 3, adding the multiple $\sqrt{2}$, we have the rise for each second $11\sqrt{2}$, $9\sqrt{2}$, $7\sqrt{2}$, $5\sqrt{2}$, $3\sqrt{2}$ and $1\sqrt{2}$; total, $36\sqrt{2}$ S. The fall by gravity from Y to A, or from G to X, remains as in the fourth line of the same table, and the range AX will be the square root of the difference of the squares of the other two sides of the triangle A G X.

6. It is with this diagonal that we have henceforth to deal. For the mere convenience of using such small figures, I shall now work out the question fully, of the range for varying angle of elevation, or time of flight, for this very small velocity, $12\,S\sqrt{2}$, or 272·9 feet per second.

7. Whatever be the elevation, we will suppose the initial velocity to be $12\,S\sqrt{2}$; then the resistance of the atmosphere would overcome this in 7·1352 seconds, and we may at once calculate the ranges for any time of flight, and for any elevation greater than 45°. The easier question shall be taken first, viz., the range for time of flight.

8. The range we have just seen to be the square root of the difference of the squares of the hypothenuse and perpendicular, we must therefore be able to read off the graduation of the hypothenuse for time, before we can calculate by it. The hypothenuse is exactly the third line of the table in par. 3, as far as it goes, with the addition of the multiple $\sqrt{2}$; we may therefore graduate for ascending flight the line AY of par. 2. For even seconds this has been done, thus—

For seconds of time,	1	2	3	4	5	6
the ascent for each	$S\times 11$	9	7	5	3	1
reaching to	$S\times 11$	20	27	32	35	36
Or, to 6^2 S, minus	$S\times 5^2$	4^2	3^2	2^2	1^2	0

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In this last line lies the key to the graduation for fractional parts of seconds.

9. For any fraction of a second, the ascent is thus obtained: From 6 seconds deduct the named time, say $4\frac{1}{2}$ seconds; there remains $1\frac{1}{2}$. Then from the square of 6 take the square of $1\frac{1}{2}$ for the ascent required, $36-2·25=33·75$, the ascent for $4\frac{1}{2}$ seconds, and $33·75\sqrt{2}$, the portion of hypothenuse for $4\frac{1}{2}$ seconds time of flight.

10. We may now proceed to give the ranges for even seconds.

Time.	Ascent, squared.	Descent, squared.	Range.	Logarithmic Sine.	Elevation.
1	$11\sqrt{2^2} = 242$	1 1	$\sqrt{241} = 15·524$	8·80809232	3° 41′
2	$20\sqrt{2} = 800$	4 16	$\sqrt{784} = 28$	9·151515	8 8
3	$27\sqrt{2} = 1458$	9 81	$\sqrt{1377} = 37·108$	9·37236375	13 38
4	$32\sqrt{2} = 2048$	16 256	$\sqrt{1792} = 42·232$	9·548455	20 $42\frac{1}{3}$
5	$35\sqrt{2} = 2450$	25 625	$\sqrt{1825} = 42·72$	9·703357	30 20
6	$36\sqrt{2} = 2592$	36 1296	$\sqrt{1296} = 36$	9·849485	45
7	2592	49 2401	$\sqrt{191} = 13·82$	9·9833786	71 $14\frac{2}{3}$
7·135	2592	50·912 = 2592	0 = 0·	10	90

11. Here we see the longest range will be somewhere between the times 4 and 5 seconds. We will therefore give a table of each of the tenths of seconds between these two, as follows:—

Time.	Hypothenuse, squared.	Descent, squared.	Range, squared.	Sine of	Elevation.
4	$32\ \sqrt{2^2} = 2048$	256	1792	9·5484550	
4·1	$32·39\sqrt{2} = 2098$	282·5761	1815·6481	·5646418	
4·2	$76\sqrt{2} = 2146$	311·1696	85·2656	·5806397	
4·3	$33·11\sqrt{2} = 93$	341·8801	50·6641	·5964627	
4·4	$44\sqrt{2} = 2236$	374·8096	61·6576	·6121241	
4·5	$75\sqrt{2} = 78$	410·0625	68·0625	·6276362	
4·6	$34·04\sqrt{2} = 2317$	447·7456	69·6976	·6430111	26° 4′ 30″
4·7	$31\sqrt{2} = 54$	487·9681	67·3841	·6582600	
4·8	$56\sqrt{2} = 88$	530·8416	57·9456	·6733938	
4·9	$79\sqrt{2} = 2421$	576·4801	44·2081	·6884228	
5	$35\ \sqrt{2} = 50$	625	1825	9·703357	

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The longest range is very near 4·6 seconds.

12. I therefore tried 4.59, 4·58, and 4·57, as follows:—

4·57	$33·95512\sqrt{2} = 2305·9$	436·179	1869·721		
8	$33·9836\sqrt{2} = 2309·77$	440·01	1869·76	9·6399466	25·53
9	$34·0119\sqrt{2} = 2313·605$	443·865	1869·735		

And this I consider a sufficiently near approximation to the maximum range for this velocity, being worked to hundredth parts of seconds of time. The range being the root of 1869·76 is 43·243 S, the longest possible with this velocity.

13. This agrees very well with that given in my letter of date 20th April 1857, addressed to the President of the Select Committee of the Royal Regiment of Artillery, Woolwich, and I have lately heard that the French instructors of musketry have ascertained by actual experiments, that 26° is the angle for greatest range. I asked for the one experiment, "Does, or does not, elevation of 25° 53 give maximum range to shot or shell;" and I think it much to be regretted that the Royal Artillery refused to try so simple and easy an experiment. I have no doubt I shall receive, very soon, the results of the trials I asked the three commandants of the East Indian regiments to order for me.

14. We now come to the next question, viz., Range for Elevation. The first part of this is very easy, that which relates to elevation greater than 45°. We have only to work out eight questions, the first of which I will state. As $90^\circ : 36\sqrt{2} :: 50^\circ :$ the perpendicular, and :: cosine of 50° : range. Hence the following table—

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Elevation.	Perpendicular and Time.		Range.
45°	36	6	36
50°	39	6·24507	32·725
55°	41·7044	6·4579	29·2017
60°	44·091	6·6401	25·456
65°	46·1417	6·7928	21·516
70°	47·8413	6·91815	17·413
75°	49·117	7·0126	13·177
80°	50·286	7·0912	7·96435
85°	50·718	7·1216	4·43725
90°	50·911	7·135	0·0

15. But for angles less than 45° far greater complication presents itself. I will give my table first, and then show the working out of one, the most important of these angles—

Elevation.	Perpendicular and Time.		Range.	
45°	36	6	36	
40°	32·651	5·71421	38·912	
35°	28·884	5·37436	41·25	
30°	24·706	4·97054	42·7926	
25°	20·1535	4·4893	43·21936	
20°	15·304	3·912	42	
15°	10·3387	3·21539	38·585	log. 1·5864158
10°	5·59912	2·36625	31·7545	
5°	1·7342	1·3169	19·8823	

16. I now proceed to show how I found the range for 15° elevation—

First—Say, as 90° : $36\sqrt{2}$ :: sin. 15° : 13·177=XG the perpendicular. The root of this is 3·63 seconds; we used the hypothenuse for 6 seconds, substitute that for 3·63, which is 30·3831. In this manner,

Second—Say, as 90° : $30{\cdot}3831\sqrt{2}$ :: 15 : 11·12 amended value of XG, and proceed as before. The following table will best show the very tedious nature of the process.

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Table of the working out of the range for 15°

$V = 12\,S\sqrt{2}.$

As sin. 90° : hypothenuse :: 15° : GX.

Hypothenuse.	15° : GX and		$\sqrt{GX}$.	$6-\sqrt{GX}$.	$(6-\sqrt{GX}.)^2$	$36-(6-\sqrt{GX})^2$
$\sqrt{2}$	9·4129962	13·177	3·63	2·37	5·6169	30·3831
$30·38\sqrt{2}$		11·12	3·3334	2·6666	7·1075	28·8924
$28·8\sqrt{2}$		10·5415	3·24675	2·7532	7·579	28·421
$28·3\sqrt{2}$		10·3585	3·21846	2·7815	7·7356	28·2716
$28·25\sqrt{2}$		10 3402	3·21562	2·7843	7·75	28·248
$28·246\sqrt{2}$		10·3387	3·2154	2·7846	7·7536	28·246

Here we have, after six trials, the hypothenuse corresponding with the perpendicular; we therefore get the range, in either of these two ways—As 90 : $28·246\sqrt{2}$ :: cosine of 15° : 38·585 the range, or $28·246\sqrt{2}$ squared—10·3387 squared = 38·585 squared.

17. I have now shown how to find the range for any time of flight or for any angle of elevation, with velocity so small as to be of no practical use, but used for the purpose of letting the eye embrace at one glance the whole table; I now give the same tables for a velocity exceeding what we can ever hope to give on actual service, viz. 2000 feet per second.

18. A ball falling from Y to A in 44 seconds of time, as in par. 1, would fall through $44^2 S = 1936 S$, acquiring velocity 88 S. The same ball, fired upwards from A with initial velocity 88 S, would ascend, if unimpeded by gravity, from A to Y exactly, 1936 S. The same ball receiving at the same exact moment horizontal velocity equal to the vertical velocity, would be urged in the direction AG, the diagonal of the equal forces AY and AX, formed into a parallelogram AYGX, and the ball's horizontal range will be, for any angle, the square root of the difference of the squares of AG and GX.

19. I give the following tables: Table A is the same as that in par. 1, enlarged from 6 to 44; Table B is the same,

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read in the reverse direction; Table C is the result of Table B, with the multiple $\sqrt{2}$ added; Table D shows the square of the perpendicular for any time of flight in even seconds, and the square of the hypothenuse for the same; their difference is then shown, and its square root is the base or range in spaces of $16\frac{1}{12}$. Its elevation is easily got, the three sides of a right-angled triangle being given. The range is given in yards in a sixth column. Table E shows the elevation obtained by simple trigonometry, having perpendicular and hypothenuse of a right-angled triangle. It is given to serve with more perfect exactness the next calculation. Table F shows the range for all angles of elevation, 5°, 10°, 15°, and so on to 90°, with a small supplementary table for calculating some of the tables most generally given in our books, especially in Douglas's Naval Gunnery.

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Initial velocity = 2000 feet per second.

TABLE A.				TABLE B.				TABLE C.
DESCENT BY GRAVITY.				ASCENT, VERTICAL, VELOCITY 88 S.				DIAGONAL ASCENT OR HYPOTHENUSE.
Seconds of Time.	Spaces, S, for Whole Time.	Spaces, S, for each Second.	Velocity acquired.	Seconds of Time.	Velocity.	Spaces, S, ascended in each second.	Spaces, S, ascended in whole times, and the way to calculate this.	
1	1	1	2	1	88	87	$87 = 44^2 - 43^2$	$87\sqrt{2}$
2	4	3	4	2	86	85	172 .. 42^2	$172\sqrt{2}$
3	9	5	6	3	84	83	255 .. 41^2	$255\sqrt{2}$
4	16	7	8	4	82	81	336 .. 40^2	$336\sqrt{2}$
5	25	9	10	5	80	79	415 .. 39^2	$415\sqrt{2}$
6	36	11	12	6	78	77	492 .. 38^2	$492\sqrt{2}$
7	49	13	14	7	76	75	567 .. 37^2	$567\sqrt{2}$
8	64	15	16	8	74	73	640 .. 36^2	$640\sqrt{2}$
9	81	17	18	9	72	71	711 .. 35^2	$711\sqrt{2}$
10	100	19	20	10	70	69	780 .. 34^2	$780\sqrt{2}$
11	121	21	22	11	68	67	847 .. 33^2	$847\sqrt{2}$
12	144	23	24	12	66	65	912 .. 32^2	$912\sqrt{2}$
13	169	25	26	13	64	63	975 .. 31^2	$975\sqrt{2}$
14	196	27	28	14	62	61	1036 .. 30^2	$1036\sqrt{2}$
15	225	29	30	15	60	59	1095 .. 29^2	$1095\sqrt{2}$
16	256	31	32	16	58	57	1152 .. 28^2	$1152\sqrt{2}$
17	289	33	34	17	56	55	1207 .. 27^2	$1207\sqrt{2}$
18	324	35	36	18	54	53	1260 .. 26^2	$1260\sqrt{2}$
19	361	37	38	19	52	51	1311 .. 25^2	$1311\sqrt{2}$
20	400	39	40	20	50	49	1360 .. 24^2	$1360\sqrt{2}$
21	441	41	42	21	48	47	1407 .. 23^2	$1407\sqrt{2}$
22	484	43	44	22	46	45	1452 .. 22^2	$1452\sqrt{2}$
23	529	45	46	23	44	43	1495 .. 21^2	$1495\sqrt{2}$
24	576	47	48	24	42	41	1536 .. 20^2	$1536\sqrt{2}$
25	625	49	50	25	40	39	1575 .. 19^2	$1575\sqrt{2}$
26	676	51	52	26	38	37	1612 .. 18^2	$1612\sqrt{2}$
27	729	53	54	27	36	35	1647 .. 17^2	$1647\sqrt{2}$
28	784	55	56	28	34	33	1680 .. 16^2	$1680\sqrt{2}$
29	841	57	58	29	32	31	1711 .. 15^2	$1711\sqrt{2}$
30	900	59	60	30	30	29	1740 .. 14^2	$1740\sqrt{2}$
31	961	61	62	31	28	27	1767 .. 13^2	$1767\sqrt{2}$
32	1024	63	64	32	26	25	1792 .. 12^2	$1792\sqrt{2}$
33	1089	65	66	33	24	23	1815 .. 11^2	$1815\sqrt{2}$
34	1156	67	68	34	22	21	1836 .. 10^2	$1836\sqrt{2}$
35	1225	69	70	35	20	19	1855 .. 9^2	$1855\sqrt{2}$
36	1296	71	72	36	18	17	1872 .. 8^2	$1872\sqrt{2}$
37	1369	73	74	37	16	15	1887 .. 7^2	$1887\sqrt{2}$
38	1444	75	76	38	14	13	1900 .. 6^2	$1900\sqrt{2}$
39	1521	77	78	39	12	11	1911 .. 5^2	$1911\sqrt{2}$
40	1600	79	80	40	10	9	1920 .. 4^2	$1920\sqrt{2}$
41	1681	81	82	41	8	7	1927 .. 3^2	$1927\sqrt{2}$
42	1764	83	84	42	6	5	1932 .. 2^2	$1932\sqrt{2}$
43	1849	85	86	43	4	3	1935 .. 1^2	$1935\sqrt{2}$
44	1936	87	88	44	2	1	$1936 = 44^2$.	$1936\sqrt{2}$

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TABLE D.

Seconds of time.	Square of the Perpendicular.	Square of the Hypothenuse.	Square of the Base.	Range in Spaces, S.	Elevation.		Range Yards.	Seconds of Time.
					°	′		
1	1	15138	15137	123		27	660	1
2	16	59168	59152	243		56	1304	2
3	81	130050	129969	360·52	1	25	1933	3
4	256	225792	225536	474·91	1	55	2546	4
5	625	344450	343825	586·37	2	26	3144	5
6	1296	484128	482832	694·7	2	57	3724	6
7	2401	642798	640577	800·37	3	30	4291	7
8	4096	819200	815104	902·83	4	3	4840	8
9	6561	1011042	1004481	1002·24	4	37	5373	9
10	10000	1216800	1206800	1098·5	5	12	5898	10
11	14641	1434818	1420177	1191·7	5	47	6389	11
12	20736	1663488	1642752	1281·7	6	24	6871	12
13	28561	1901250	1872689	1368·4	7	2	7336	13
14	38416	2146592	2108176	1451·95	7	41	7784	14
15	50625	2398050	2347425	1532·13	8	21	8214	15
16	65536	2654208	2588672	1608·93	9	2	8626	16
17	83521	2913698	2830177	1682·31	9	44	9619	17
18	104976	3175200	3070224	1752·2	10	20	9394	18
19	130321	3437442	3307121	1818·55	11	13	9750	19
20	160000	3699200	3539200	1881·3	12	0	10073	20
21	194481	3959298	3764817	1940·59	12	46	10402	21
22	234256	4216608	3982352	1995·59	13	37	10699	22
23	279841	4470050	4190209	2047·	14	29	10974	23
24	331776	4718592	4386816	2094·32	15	22	11228	24
25	390625	4961250	4570625	2137·9	16	17	11461	25
26	456976	5197088	4740112	2166·66	17	14	11672	26
27	531441	5425218	4893777	2212·19	18	14	11860	27
28	614656	5644800	5030144	2242·8	19	16	12024	28
29	707281	5855042	5147761	2268·87	20	20	12164	29
30	810000	6055200	5245200	2290·25	21	27	12278	30
31	923521	6244578	5321057	2306·7	22	37	12367	31
32	1048576	6422528	5373952	2318·15	23	49	12428	32
33	1185921	6588450	5402529	2324·33	25	6	12461	33
34	1336336	6741792	5405456	2324·96	26	26	12461·4	34
35	1500625	6882050	5381325	2319·77	27	50	12437	35
36	1679616	7008768	5329152	2308·5	29	18	12376	36
37	1874161	7121538	5247377	2290·75	30	51	12281	37
38	2085136	7220000	5134864	2268·65	32	30	12162	38
39	2313441	7303842	4990401	2233·92	34	14	11976	39
40	2560000	7372800	4812800	2193·81	36	6	11761	40
41	2825761	7426658	4600887	2144·96	38	5	11499	41
42	3111696	7465248	4353552	2086·51	40	12	11186	42
43	3418801	7488450	4069649	2017·83	42	30	10815	43
44	3748096	7496192	3748096	1936·	45	0	10379	44
45	4100625		3395567	1842·7	47	41		45
46	4477456		3018736	1737·45	50	36		46
47	4879681		2616511	1617·56	53	47		47
48	5308416		2187776	1479·	57	18		48
49	5764801		1731391	1315·785	61	16		49
50	6250000		1246192	1116·35	65	56		50
51	6765201		730991	854·98	71	48		51
52	7311616		184576	429·623	80	58		52

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TABLE E.*

Seconds of Time.	Perpendicular.	Hypothenuse.	Logarithmic Sine of angle of elevation.	Elevation. °	′	″	Range in Yards.	Range in Miles.
1	1	$87\sqrt{2}$	7·9099657		27		66	
2	4	$172\sqrt{2}$	8·2160166		56		1304	
3	9	$255\sqrt{2}$	8·3971873	1	25		1933	1
4	16	$336\sqrt{2}$	8·5272657	1	55		2546	
5	25	$415\sqrt{2}$	8·6293769	2	26		3144	
6	36	$492\sqrt{2}$	8·7138224	2	57		3724	2
7	49	$567\sqrt{2}$	8·7860980	3	30		4291	
8	64	$640\sqrt{2}$	8·8494850	4	3		4840	
9	81	$711\sqrt{2}$	8·9061004	4	37		5373	3
10	100	$780\sqrt{2}$	8·9573904	5	12		5898	
11	121	$847\sqrt{2}$	9·0043870	5	47		6389	
12	144	$912\sqrt{2}$	9·0478527	6	24		6871	
13	169	$975\sqrt{2}$	9·0883671	7	2		7336	4
14	196	$1036\sqrt{2}$	9·1263813	7	41		7784	
15	225	$1095\sqrt{2}$	9·1622534	8	21		8214	
16	256	$1152\sqrt{2}$	9·1962725	9	2		8626	
17	289	$1207\sqrt{2}$	9·2286756	9	44		9619	5
18	324	$1260\sqrt{2}$	9·2542644	10	20		9394	
19	361	$1311\sqrt{2}$	9·2893895	11	13		9750	
20	400	$1360\sqrt{2}$	9·3180061	12	0	12	10073	
21	441	$1407\sqrt{2}$	9·3446295	12	46	30	10402	
22	484	$1452\sqrt{2}$	9·3723628	13	37		10699	6
23	529	$1495\sqrt{2}$	9·3982995	14	29		10974	
24	576	$1536\sqrt{2}$	9·4235163	15	22		11228	
25	625	$1575\sqrt{2}$	9·4480844	16	17		11461	
26	676	$1612\sqrt{2}$	9·4720667	17	14		11672	
27	729	$1647\sqrt{2}$	9·4955189	18	14		11860	
28	784	$1680\sqrt{2}$	9·5184918	19	16		12024	
29	841	$1711\sqrt{2}$	9·5410310	20	20		12164	
30	900	$1740\sqrt{2}$	9·5631782	21	27		12278	
31	961	$1767\sqrt{2}$	9·5849718	22	37		12367	7
32	1024	$1792\sqrt{2}$	9·6064470	23	49		12428	
33	1089	$1815\sqrt{2}$	9·6276363	25	6		12461	
34	1156	$1836\sqrt{2}$	9·6485701	26	26		12461·4	7 0 141·4
35	1225	$1855\sqrt{2}$	9·6692772	27	50		12437	
36	1296	$1872\sqrt{2}$	9·6897841	29	18		12376	7
37	1369	$1887\sqrt{2}$	9·7101166	30	51		12281	
38	1444	$1900\sqrt{2}$	9·7302986	32	30		12162	
39	1521	$1911\sqrt{2}$	9·7503525	34	14		11976	
40	1600	$1920\sqrt{2}$	9·7703038	36	6		11761	
41	1681	$1927\sqrt{2}$	9·7901710	38	5		11499	
42	1764	$1932\sqrt{2}$	9·8099765	40	12	43·6	11186	
43	1849	$1935\sqrt{2}$	9·8297409	42	30	25	10815	6
44	1936	$1936\sqrt{2}$	9·8494850	45			10379	
45	2025		9·8690047	47	41			
46	2116		9·8880953	50	36			
47	2209		9·9067753	53	47			
48	2304		9·9250621	57	18			
49	2401		9·9429718	61	16			
40	2500		9·9605196	65	56			
51	2601		9·9777200	71	48			
52	2704		9·9945863	80	58			

* Referred to in Page 534.

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TABLE F.

Elevation.	Time of Flight, in Seconds.	Range, in	
		Spaces of 16 1/12 feet.	Yards.
5	9·6563	1065·771	5713·77
10	17·35	1707·2	9152·52
15	23·5795	2075·	11124·26
20	28·688	2261·168	12122·37
25	32·92	232·406	12459·6
30	36·45	2301·3	12335·
35	39·4124	2218·4	11893·07
40	41·9035	2092·6	11218·66
45	44·	1936·	10379·11
50	45·797	1759·9	9435·02
55	47·3579	1570·4	8419·22
60	48·694	1369·	7339·15
65	49·8136	1157·1	6203·31
70	50·7228	936·42	5020·27
75	51·426	708·625	3799·02
80	51·926	475·435	2548·85
85	52·2255	238·322	1279·3
90			

SUPPLEMENT TO TABLE F.

10°	17·35	1707·2	9152·52
11°	18·7	1799·01	9644·7
12°	20·	1881·3	10085·
13°	21·2378	1953·73	10474·2
14°	22·4318	2018·17	10819·7
15°	23·5795	2075·	11124·26

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TABLE G.

Elevation
15°

Yards Range.	Logarithm $= r$.	R.	Logarithm of $\frac{R}{r}$	Logarithm of $\sqrt{\frac{R}{r}}$	V.	Logarithm of $\frac{V}{\sqrt{\div r}}$	V, in feet.
4001	3·6021686	R = 11124·26 log. 4·04627116	0·44410256	0·22205128	2001·5 by 3·30137373	3·07932245	1200·4
3585	3·5544892		0·49178196	0·24589098		3·05548275	1136·2
3546	3·5497387		0·49653246	0·24826623		3·05310750	1130·2
3534	3·5482665		0·49800466	0·24900233		3·05237140	1128·2
3513	3·5456781		0·50059306	0·25029653		3·05107720	1124·8
3499	3·5439439		0·50232726	0·25116363		3·05021010	1122·56
3469	3·5402043		0·50606686	0·25303343		3·04834030	1117·74
3444	3·5370631		0·50921806	0·25460403		3·04676970	1113·7
3391	3·5303278		0·51594336	0·25797168		3·04340205	1105·1
3359	3·5262100		0·52006116	0·26003058		3·04134315	1099·87
3284	3·5164031		0·52986806	0·26493403		3·03643970	1087·53
3193	3·5041989		0·54207226	0·27103613		3·03033760	1072·35
3152	3·4985862		0·54768496	0·27384248		3·02753125	1065·445
Elevation 35°							
5600	3·7481880	11893·07 4·0752914	0·3271034	0·1635517	3·01373733	3·13782203	1373·5
5437	3·7353593		0·3399321	0·16996605		3·13140768	1353·34
5200	3·7160033		0·3592881	0·17964405		3·12172968	1323·5
Elevation 30°							
4785	3·6798819	12335·0 4·0911392	0·4112573	0·20562865	V.	3·09574508	1246·65

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20. Having now tables of range for time of flight or range for elevation, with the velocity 2000 feet per second, it is easy to give the initial velocity for any given range in our practice books, double velocity gives four times the range, three times the velocity gives nine times the range.

21. I will work out an example. At 30° elevation, a shot ranged 4785 yards. With velocity 2000, the same elevation gave 12335 yards, and $\frac{12335}{4785} = 2\cdot57785$, the square root of which is 1·605565. Dividing 2000 by 1·605565, we get 1246·5, the velocity, which at 30° would throw its shot 4785 yards.

22. This result differs widely from that which I gave in my letter, dated 4th February 1857. I therein gave the velocity 1546·36. My error lay in calling the hypothenuse 1030·615, instead of calling it $670\cdot788\sqrt{2}$, which is the same thing, but leads to a different result. Had I taken S, the sum of all the terms, as 670·788 instead of 1030·615, I should have worked thus: $\frac{E+e}{2} \times n =$ the sum of the series, 670,788. Therefore $\frac{E+e}{2} = 670\cdot708$ divided by n, the number of terms, gives $\frac{E+e}{2} = 321\cdot03$ or $E + e = 642\cdot06$. And, as before, we have

$$E - e = 454.$$

$$\text{Therefore } 2\,E = 1096 \text{ and } E = 548.$$

And E being 548, the time of flight is 27·4 seconds, the initial velocity $27\cdot4 \times 32\frac{1}{6}\sqrt{2} = 27\cdot4 \times 45\cdot49 = 1246\cdot5$, the initial velocity as found in par. 21.

23. This unlucky oversight vitiates the results of the table contained in my letter of date 24th February, where the same blunder occurs throughout the 9th column, and of course the 10th, 11th, and 12th. I give herewith a corrected Table G of Velocities for the sixteen ranges therein treated, and I shall feel much obliged to any gentleman who

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will examine the correctress of the arithmetical part of a work. I made sure that by inviting the criticism of the ma-thematical professor of Woolwich, any inaccuracy of mere arithmetic was certain of detection.

24. I am quite sure that if I am wrong in the results I draw from the premises, I am yet in the right way to follow up the enquiry. I wish I had access to sufficient tables of practice, and had the means of verifying the conclusions of my theory by experiment occasionally; but I have no chance of obtaining either the one or the other in England, and I do not think my health will enable me to return to India.

25. I must therefore delegate to younger and more fortu-nate men the pleasant task I had hoped to work out myself, to show how we may, with the means in our power, at every considerable artillery station, be quite independent of the ex-pensive ballistic pendulum, and yet bring the science to a high degree of accuracy, and almost to perfection.

26. Particularly, I hope that Lieut.-Colonel Croggan of my own regiment will employ his leisure in this work. He started before me in this very course, and has opportunities of carrying out his experiments, as every artillery officer has in India, at least on the Madras side.

P. ANSTRUTHER, *Colonel,*
Major of Madras Artillery.

Belchester, by Coldstream,
December 14*th*, 1857.

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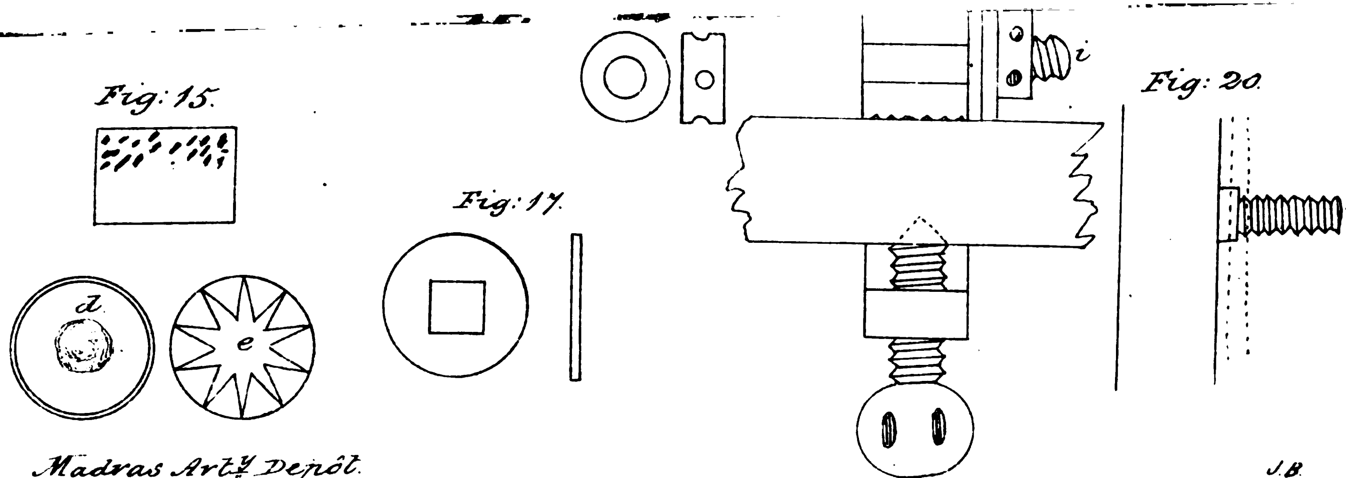

Madras Art.y Depôt.

J.B.

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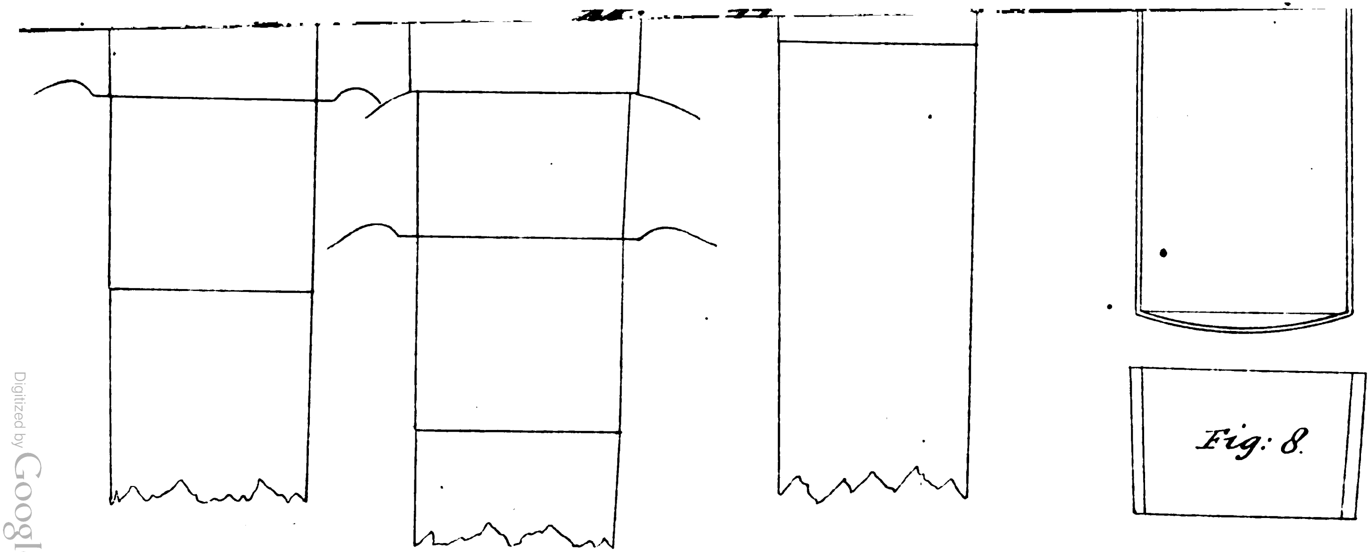

Fig: 8.

Madras Arty Depôt

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Description of Fuze and portable Vice for the more accurate sawing of Fuzes, by Captain C. D. Waddell. Plate 30.

COONOOR *22d January* 1858.

MY DEAR MAJOR ROWLANDSON,

I send you the fuze I would propose, which I referred to before, which if you think worth notice, I shall be glad if you will insert in the Records.

(Signed) C. D. WADDELL.

It has struck me that when irregular sized Fuze holes and Fuzes are superseded by both accurately turned and fitted to each other, a difficulty will arise in fixing them in Tropical climates; in the comparatively even hygrometric state of the air in Europe, a Fuze turned to an exact size may not vary from it according to the condition of the atmosphere to any appreciable extent, but here it may be anticipated the case would be different; Suppose as in Fig. 1, a Fuze of the tapering form of Boxer's, made in Europe, exactly adapted to its Fuze-hole and requiring to be driven exactly one inch to its proper position as in Fig. 2; let this Fuze be sent out here, and tried to be set in the Rains at Khiouk-phyoo, say; now according to the taper Boxer gives his Fuzes, which is as 16·2 inches to 1·22 of an Inch, the difference of thickness in 1 inch of length is only ·075 of an Inch, therefore supposing this Fuze from the extreme moisture to have swelled throughout by ·075 of an inch,—which I think is so small an expansion, as to be by no means impossible in a very humid atmosphere,—Fig. 3 will show it just entering and Fig. 4 driven with the same force and to the same distance as the Fuze in Fig. 2, but having by far too great an excess above the surface of the shell; now suppose another of this same Fuze tried to be set, say at Kamptee, in May, with the scorching winds and highly dry atmosphere and that it has on the contrary shrunk in its size by ·075 of an Inch, Fig. 5 shows it going into the Fuze hole loose to the place to which it should have arrived tightly driven, and Fig. 6 shows it

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half driven into the Shell before it can be equally securely fixed as the fuze in Fig. 2, the quick match round the head being of course sacrificed. It therefore seems to me that the slope of the cone in Boxer's Fuze is too small to be adapted for use in climates, where there is such a great range between extreme humidity and dryness, and that it will be found to fail in use in the Colonies: it is quite clear that Boxer gave his fuze this slight taper to prevent it, riddled as it is with perforations, from crushing in driving, which it would be liable to do if the angle of its sides was greater, but even with a more obtusely sloped cone, the objections arising from the expansion and contraction of wood, would still exist, although they would not cause so great a range between too tight and too loose as in Boxer's, and they seem to me to indicate that a more satisfactory way of fixing fuzes, is to be arrived at, by not depending on the direct gripe that the wood of the fuze can exert on the fuze hole, but I would propose metal should be made to serve this purpose, in the following manner: Fig 7 represents, in vertical section through its axis, a brass bouch with Powder Cylinder on Boxer's plan for a 24 Pdr. S. C. S., the thread in the shell being iron should be thin and sharp, that in the bouch round and full, screwing to a shoulder at *a*, the bouch has also a shoulder in its interior at *b*, which is tapering and serrated with rings cut in it in turning: Fig. 8 represents the vertical section of a similarly tapering hollow cylinder of very soft cast lead, which should fit easily into the bouch, it is seen in plan in Fig. 9—Fig. 10 is a hollow cylinder of Iron seen in vertical section in Fig. 11 and in plan in Fig. 12; it is similarly tapering on its outer surface, which meets the inner cylindrical surface in a knife edge at the bottom, a small part of its head is cylindrical and fitted with three spiral grooves, for the attachment of a fire-proof Cap Fig. 13, to be explained presently; this Iron Cylinder should be roughed externally and just such a size, as to enter one third of its height into the interior of the leaden cylinder. The

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Fuze is seen in section in Fig. 14, its head is cylindrical to a certain distance where it has a shoulder and a washer of leather, the inner edge of which, to secure it, should be let into the wood of the Fuze, say the 40th of an inch, the form of the Fuze is then continued diminished by the depth of the shoulder, not tapering but cylindrical, to the length required for a S. C. Fuze. The cup of the Fuze is so formed as to leave an annular recess at the bottom of it, the object of which is to effectually hold a ring of 3 pieces of quick match twisted together, and having their 6 ends left in excess to stand well out of the Fuze cup; in the Figure they are shewn turned down into the Fuze cup under the fire-proof Cap. The ring of quick Match, should, when the fuze is driven, be inserted moist and imbued with wet mealed powder and pressed into the recess with a wooden former, so that its inner surface should abut upon the head of the column of Fuze composition, without covering it, and leaving a clear hole in the centre, down to it. The ordinary quick match, although well enough adapted for use in straight lengths, is not suited to tieing or bending, for such purposes I would suggest, a piping of fine muslin being made having the strands of cotton saturated with wet mealed powder, loosely drawn into it, and being itself also saturated and loaded with the mealed powder, I think this would bear knotting or bending, better, the muslin retaining the dry mealed powder caked on the cotton, which falls off at every touch, in the ordinary match.—To set this fuze, the leaden ring Fig. 8 must be first put into the bouch, then the Fuze, and then the conical Iron ring Fig 10 its knife edge being inserted between the leaden ring and the Fuze, it should then be driven in, with a mallet and setter, until the inner and lower surface of its head comes home upon the head of the Fuze. The Fuze should fit easily into the iron cylinder, allowing for expansion and contraction of the wood. The leaden ring will be expanded in this operation and the lead compressed into the serrated rings in the bouch, thus forming an effectu-

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al fire-proof joint.—The fire-proof Cap referred to, is affixed to the head of the Fuze when set in a live shell, thus enabling shells to be kept loaded, with Fuze thoroughly prepared and to be carried in the ammunition boxes with perfect safety, Fig. 13 is this Cap of iron, it has 3 claws, which are adapted to enter the spiral grooves in the head of the Iron cylinder, already described, it screws tightly on the head of the latter, it should be milled on the top, as a hold in turning it, and its under side should have a disk of thin leather glued into it, to ensure a tight joint.

When Spherical shot with short lengths of Fuze are sometimes required, I think it would be a good plan to have the first half inch of the column of composition at the head of the Fuze, of quick burning composition of mealed powder, say to burn 1 inch in 2 seconds, and thence downwards, the ordinary composition, this would obviate cutting off to the inch and boring out the difference, by always leaving enough wood for the shoulder in ordinary Fuzes, even if cut but for a second's flight; I have applied it in this fuze for another reason, viz: to allow of wood being available for the fixing of a lower priming cup (to be described further on) when the Fuze is cut to the shortest length required. I doubt if mealed composition would stand the ·4 of an inch boring in Boxer's Fuzes, or would have added it here. Although with the Powder Cylinder, the sawn end of the Fuze must always be pretty near the surface of the bursting powder, and it can seldom happen that it will fail to ignite it, yet, as I have noticed in a former paper, the last burning out of the Fuze, is a weak point in the chain of ignition, which it would be desirable to obviate, I would propose a priming cup for this purpose, which would make certainty double sure, it is so simple and inexpensive, that I think it would be worth applying generally to all Fuzes; Fig. 15 seen in plan from above, at *d* and in plan from below at *e* is a thin cylindrical cup of sheet tin formed out of a piece, a little longer than the circumference of the sawn end of the Fuze,

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(to allow for the soldered joint) by about $\frac{3}{4}$ of an inch wide, having $\frac{1}{3}$ of this width, or one of its longest sides clipped into vandykes to be turned in at more than a right angle with the side of the cylinder when formed, to serve as a bottom, it should, before forming, be punched from the intended outside, with a fine awl, with elongated holes as in the Figure slightly inclined, the burrs round the edges of these holes being left projecting internally, to act as portions of screw threads, when it is screwed on to the sawn end of the Fuze; into the bottom of this cup a disk of paper or cloth should be pasted, and a little fine powder put in to about $\frac{1}{3}$ fill it, over this a coil of quick match should be placed, which should be highest in the centre, and another disk of paper or cloth pasted over this having a round hole in the middle of it of the size of the end of the column of Fuze composition, the coil of match might be imbedded with the addition of some moist mealed powder, to prevent the fine powder escaping between the coils of the match; when the Fuze is sawn, this priming cup should be screwed on to the end of it, see Fig. 15, till the surface of the quick match exposed in its centre, comes in close contact with the end of the Fuze, connected with the general application of this cup to all Fuzes, is their external form, it seems to me that the form of a frustrum of a cone, for the whole length of Fuzes, is unnecessary, there can be only a certain part in the head of a Fuze properly set, within the limits of which, the taper is necessary for the hold in the Fuze hole, and thence downwards, if made a uniform cylinder, this cup could be used with any Fuze.

The most accurate sawing of this Fuze to exact length required, can be effected with a modified and much more portable form of vice, than that now used, and indeed with any other Fuzes made to a fixed cylindrical size, at the part where the tenth rings are marked, instead of conical as at present, this guide vice could be most advantageously applied.

Fig. 16 is this vice, seen in front elevation, it is clamp-

ed to a table by the lower screw, and above are the jaws of a vice, notched to hold the Fuze, they work on a hinge at one side and tighten upon the Fuze, by a screw on the other, the part of the Fuze held in this vice, being the same size for each Fuze, very little play for the jaws is required; at *i* a stout pin projects, which is four sided for a little way and then tapped for a screw and a nut. Fig. 17 is an Iron washer, which should be the same thickness as, or only a hair's breadth thicker than the saw used to cut the Fuzes; it has a square hole in its centre by which it fits on to the pin. Fig. 18 is a guide-plate of Iron exactly one tenth of an inch thick, seen in section at *c*; above, it has a circular hole in it, a very little larger than the Fuze, and below, a square hole by which it is put on to the pin *i* Fig. 16, and over the washer thus described, the square part of this pin should be a little shorter than the thickness of the washer and this guide-plate together, see Fig. 20. Fig. 19 is a nut to screw up the washer and plate tight to the face of the vice. A Fuze has only to be passed through the hole in the guide-plate into the jaws of the vice, see Fig. 21, and clamped so that the tenth ring to which it is to be cut, coincides with the inner side of the guide-plate or what is the same thing (as the guide-plate is $\frac{1}{10}$ inch thick) and easier to see, until a tenth ring *less* than the number required, coincides with the *outer* side of the plate, the saw is inserted in the space for it at *k* Fig. 21 over the washer, and the Fuze cut exactly and correctly with the greatest ease and by the most unhandy person; the head of the Fuze should be held in the left hand. The whole vice should be of Iron and to prevent the saw's teeth wearing the jaws of the vice, the inner side of the guide-plate and the washer, they might be case-hardened. The saw used with this vice, should not have its teeth bent alternately right and left, or be set as it is termed, but they should lie in the plane of the blade. I would add in conclusion that the thickness of the leaden ring, its taper, and that of the bouch and of the iron ring, require determining by

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experiment, also the depth of the serrations in the bouch, the Figures given being intended only to illustrate the principle of this method of fixing Fuzes.

Lieut.-Colonel Parlby on the flight of Projectiles.

To the Editor of the Mechanic's Magazine.

Sir,—In my last paper, the resistance of the air to the range of projectiles was alone alluded to; but there is also the effect of the constant power of what is termed gravitation to be considered. However, as gravitation acts only in one direction, causing the fall of all projected bodies, of whatever shape they may be, downwards, in a direction coinciding with the perpendicular plane of range, and having no tendency to deflect the body to the right or to the left; and as it is a constant force, well known and undisputed by all mechanical writers, producing motion through so many feet in every second of time of the projectile's flight below the line of horizontal projection, and as it is allowed for in practice by giving increased elevation to the axis of cannon and small arms as the distance to which the projectile to be thrown increases, there is no occasion to dilate upon this subject.

The great object to accomplish in the range of a cannon shot or bullet is, to prevent its being deflected to either side of the true perpendicular plane coinciding with the axis of the bore of the barrel and the point aimed at; and to make the range and the momentum of the projectile as great as possible. It was proved by the experiments of the celebrated Benjamin Robins, more than 120 years ago, that the spherical shape was the cause of the uncertainty of the range of bullets and cannon shot; yet nations have gone on to the present day using round balls!

Dr. Hutton found, in his numerous experiments with the ballistic pendulum, at Woolwich, at the end of the last century—although every precaution was used in the perfection

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of the shot and piece of ordnance, and the utmost care in weighing the charge and loading—that he could never depend upon hitting the pendulum in the proper place when the ranges exceeded 300 yards: and both these eminent men recommended the use of shot having an elongated axis. Experiments have accordingly been made in India, England, and various other nations, with oblong shot of various forms: but no satisfactory result has been produced to satisfy the practical artillerist of the present day, and many, consequently, consider the spherical form as the best.

How is this? Surely the question is easily answered:—a proper form of shot has not yet been found out. Hence, we have resorted to the rifling of barrels in various forms, and even to the monstrous mistake of the rifling cannon of large calibre, which must end in disappointment and failure;* for it is a well known fact, proved by the ballistic experiments, that even a round ball, perfectly true, and well fitted to a smooth barrel, is discharged with greater velocity than one from a rifle barrel, with the same charge of powder; and the greater velocity will give the greatest range; therefore, on this essential point, that of extent of range, the smooth has the advantage over the rifled one.

A writer in the *Morning Post*, of the 24th ultimo, Dr. Scoffern, who I believe to be a very clever chemist, alluding to Mr. Whitworth's experimental trials at Manchester, states: "Mr. Whitworth should be aware that the non rifled gun, even if it could possibly be made of one undeviating cylindrical bore throughout, must ever remain an erratic weapon." What the Doctor means by making the stationary barrel an erratic weapon, I do not understand; surely it is the shot that is discharged from it that deviates from its true path, which may be called the erratic weapon; and it is, therefore, to the shape of the shot that we must confine our attention to overcome the difficulty.

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* I shall allude to rifle barrels in my next.

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The natural medium through which the projectile has to move, as well as the circumstances attending upon its flight, I have already alluded to in my first paper. It is evident that the resistance of the air, and its friction upon the surface of the projectile, are circumstances of the utmost consequence.

Now, what do we observe in the great and truthful lessons which nature teaches us? Examine the formation of the birds of the swiftest flight, and the fishes of the most rapid courses; all have sharp terminations in their after parts—the tail feathers and the wing feathers, and the tail fins of fish, all terminate with sharp edges; and the posterior forms of their bodies slope gracefully and easily towards these sharp terminations, and thus the one passes through the highly elastic atmosphere, and the other through the denser and unelastic fluid of water, with the greatest ease and the least possible disturbance of the particles of fluid through which they pass. Now, here is a lesson which no one can dispute, taught by a being of infinite wisdom; and let us inquire how this can be applied to the form of a projectile to obtain the advantages we require.

I will state my own ideas upon the subject, and let other ingenious men improve upon them.

We require in a projectile—a solid mass to give force and momentum:—penetration is also of great consequence.

To give ease in passing through the air, I begin with a central point or pole, and as a straight line is the shortest distance between two points, I therefore choose a conical form, with the apex forwards, as the front of my shot, that giving the least surface, (for the space I require to give solidity) for the friction of the air to act upon:—and upon exactly the same rule, I make the termination of my shot a cone also; but I give that increased length, and consequently an increase of surface, because this will have a tendency to preserve the projectile in its course through the air, with its longest dia-

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meter coinciding with the line of range and to preserve the leading point of the projectile in its proper position.

The shape of my shot, therefore, is that of two cones attached to each other by their bases, as in Fig. 1, (Plate 31) and as a cone is equal to a cylinder of the same diameter and therefore one-third of its height, I have a mass in the double cone far superior to that of a round shot of the same diameter; and, therefore, having greater momentum than a round shot, and being of a form most easily and perfectly produced either in turning or moulding:—and if I desire to make it hollow for a shell or exploding shot, I have greater capacity in the same diameter, than with a spherical body—and if I wish to extend the capacity I have only to add a cylindrical part between the two cones, as in Fig. 2. (Plate 31.)

We have now to consider the position of the centre of gravity in these shot, a circumstance of considerable importance when a horizontal range is required—but not so important with shells discharged from mortars at high elevations, where the centre of gravity being in the foremost part of the shot would rather be an advantage.

To produce the best horizontal ranges, on those at low elevations, the centre of gravity should be as nearly as possible in the centre of the projectile. I propose, therefore, to cast the large shot with a hollow towards the fore part in such proportion as to bring the centre of gravity as near as possible equally distant from the two extreme points or apexes of the cones. This hollow may always be filled with explosive composition and adapted to a proper time fuze, so as to render all shot doubly destructive, and useless to an enemy.* I have also another mode of correcting the centre of gravity which I cannot now explain.

As the friction of the air upon the surface of the projec-

* In one of the Duke of Wellington's despatches, it is stated that in one of the French sieges in the Peninsula, the French artillery being without shot made use of that fired at them by the besieged.

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tile is very great, it is highly important, for correctness of range, that the surface should be as smooth as possible, and the form without defect; but as this can hardly be expected in perfection, any more than the true position of the centre of gravity can be secured, I cause my shot to revolve in the air during its flight by attaching to the posterior sloping sides, two or more projecting wings, forming a very slight angle of ¼ of a degree with the axis of the missile, thus giving it all the advantage, and the only advantage, that a ball from a rifle barrel receives.

Thus the shot is completed as in Fig. 3. (Plate 31.)

In my next I shall show the shape of a proper bottom to be applied to this shot, so as to give the best effect to the projectile power of the gunpowder, as well as to secure other very important advantages.

I am, Sir, yours, &c.,
SAMUEL PARLBY.*

Projectiles.

To the Editor of the Mechanic's Magazine.

Sir,—Having observed Lieut.-Colonel Parlby's projectiles in your last number, I may state that I have used bullets exactly the same as fig. 3, (Plate 31) only with three wings; and I doubt not, that if it were possible to get them to come out of the barrel as safe as one can put them in, they might be the best bullet yet out. I may also state, that it was the study of the swallow and the fish that made me try the same, considering that if a vacuum did not exist behind a bullet, yet there is a greater pressure on all sides than behind; and in this form of bullet, I consider that the atmosphere pressing on the foremost cone retards it, and that on the other cone or tail assists it, though not to the same extent. All this may do in theory; but when I came to use these bullets I found the flight to be pretty regular at a short distance with

* Mechanic's Magazine, 4th August 1855.

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a small charge, but when I used the usual charge they were worse than any I ever tried, sometimes taking the ground half way to the mark; and the reason of this was simply, the head being too heavy for the tail, and the lead being soft, when the bullet came out of the gun, instead of being the usual length of one five eighths, it was scarcely an inch; that is, the tail and wings were compressed till the lead filled the barrel. I should therefore be glad to hear that it was possible to send these bullets out of the gun in safety.

I am, Sir, yours, &c,,

Laysmill, August 6, 1855. GEORGE HUNTER.*

Lieut.-Colonel Parlby on the Flight of Projectiles.

To the Editor of the Mechanic's Magazine.

Sir,—In continuation of the description of my shot, proposed in your last, I may mention that it is applicable to all descriptions of fire-arms, and that the fore part of the cone, as well as the wings, may be made of malleable iron or steel, upon which the lead or cast iron may be cast; and by a due adjustment of the proportion of malleable iron, the centre of gravity, even in a solid shot, may be secured in the middle of the shot, that is, equidistant from the two ends or the apexes of the cones.

The bottom, which in using this form of shot is of most important use, is formed as represented in Fig. 4, (Plate 31) which is a perpendicular section through the middle; and in fig. 5, (Plate 31) which shows the shot and bottom complete, ready for loading, two slits, one of which is seen at *a,* being cut for the wings.

By using this bottom, which may be made of wood, paper-maché, or other suitable material, the following important results will be obtained:

1. The axis of the shot will be duly placed in the axis of bore of the barrel, and it will be retained in this advantageous position until it quits the muzzle of the gun.

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* Mechanic's Magazine, 11th August 1855.

2. The shot will be fixed or wedged in the barrel by the last stroke of the rammer, when the bottom comes in contact with the load or cartridge, so that no wad is required over the shot to keep it steady and close to the charge, even in ships of war, however violent the motion of the vessel may be.*

3. The bottom, by wedging round the shot, will prevent any of the elastic gas from escaping, whatever windage the shot may have.†

4. It will enable, in case of necessity, the use of shot of any less diameter than the bore of the gun, to be fired as truly as if they fitted the bore. Fig. 6 (Plate 31) will illustrate this—of course, supposing there is a supply of large bottoms to fit the piece.

5. It will prevent the injury to the internal surface of the bores of all guns, but particularly to those made of gun metal, from the iron shot grazing or striking along the interior, as takes place with common shot.

The bottom may be in two separate halves, fastened or tied together with pack thread or wire.

And here I may state a fact which I have often proved myself, but which may not be known to all your readers. A light body will be moved by the propelling force of gunpowder with greater velocity than a heavy one. If a common bottle cork is fired from a fowling piece or musket directly against a brisk wind, the cork will be driven out with great velocity, and will range forwards some distance; but not having sufficient momentum to overcome the reaction of the compressed air in front of the cork, it will be forced back by the reaction of the air, and will either strike the person who

* Sir Howard Douglas, in his "Naval Gunnery", Second Edition, p. 128, states that he has occasionally seen the operation of ramming home a tight wad take up two or three minutes!

† The bottom is to be formed rather concave at the end next the charge, as the first action of the propelling force will then expand it towards the interior of the bore in simultaneous action with the sliding of the fore part on the conical end of the shot, and thus effectually prevent the loss of gas by windage.

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fires it, or pass to his rear. This experiment alone proves of how little use the studies and theories of philosophers in their closets are in the practice of projectiles. It shows also how little a tight wad placed in front of a shot with windage can be available in keeping it steady as it passes along the bore, as the gas which escapes by the windage will drive the light wad out of the muzzle before the shot reaches it.

Gunpowder, it is well known, is the material we use in our fire-arms as the medium to form our projectile power; and I believe its advantages to be far superior (for this purpose) to any other chemical compound we are yet acquainted with, for reasons which I shall give as I proceed.

When gunpowder is inflamed, it produces a vast quantity of highly elastic air or gas which is supposed to exert a force by expansion of the pressure of 1,600 atmospheres, or $1600 \times 15 = 24,000$ lbs. on the square inch of surface.*

Fortunately, the inflammation of gunpowder is progressive, and not instantaneous; if it were instantaneous, there is no material that would be strong enough to resist the explosion without bursting. Attempts have been made by the mixture of chlorate of potash and other matters to improve the force of gunpowder; but they failed, either from the bursting of the gun, or the shattering of the shot, and were therefore very wisely abandoned.

It may be well, therefore, for chemists to consider that they will never be able to find a substitute for gunpowder, until they can produce a compound which will yield a great-

* This is Dr. Hutton's estimate from numerous experiments, but the exact computation of this force is a difficult attainment, as there are results attending the explosion of gun powder, under varied forms, which present some phenomena which can hardly be explained. An ounce of gun powder fired in the open air seems to produce a very harmless effect, but Count Rumford, in one of his experiments, with two ounces of this material inflamed in the chamber of a large mortar, lifted a cannon of several tons weight placed over the muzzle, and burst the mortar. In another experiment, a very large charge of many pounds was confined in a brass cannon, with the opening at the muzzle screwed up; the whole charge on being ignited, as usual, at the vent, discharged itself gradually with a loud noise, through the vent, without bursting the gun.

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er quantity of elastic gas, at the same or in less time than that in which gunpowder produces it; and the amazing force of gunpowder, when it is exploded, will at once be a convincing proof that any projects or proposed advantages with steam guns over those where gunpowder is used must be visionary.

As the inflammation of gunpowder is not instantaneous, but progressive, the consideration of this fact should not be overlooked, as it has been generally, in the construction of cannon, so that every day we hear of fatal accidents from the bursting of our cannon both by sea and land.

If the inflammation of gunpowder were instantaneous there would be no necessity for any length of barrel in the piece from which the projectile is discharged, as it would be quite sufficient to have an adequate capacity of chamber for the charge of gunpowder, and of a cylinder equal in length to a diameter or semidiameter of the shot; but we know that this will not answer in practice.

We find also that beyond a certain quantity of gunpowder in charging a cannon that we get no increase of range in the projectile discharged from any further addition to the load; for this simple reason, that the surplus quantity of the grains of powder are driven out at the muzzle before they have time to generate their due proportion of elastic fluid within the barrel of the piece, and can therefore have no possible effect upon the solid body projected; for we must always keep in mind, that all the projectile power on the shot is extinguished the moment it passes out of the muzzle of the piece, and the shot then only moves forward by the momentum which its particles of matter have received from the expansion of the elastic gas, as long as it was passing along the barrel, when the expansion was confined to one direction.

Are we therefore at once to admit that there is a limit to the range to which we can throw a projectile by the means of gunpowder? I say certainly not; whether it is one mile or

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twenty miles, the range can be effected:—for it would be very easy to ignite the largest quantity of gunpowder that could be accumulated, in 100 points at once, by means of electrical action properly applied; and thus, instead of the slow progression of igniting by one vent or touchhole, we should precipitate the production of the elastic gas one hundred fold! The only difficulty would be to construct a piece of ordnance strong enough for the purpose; but it may be done, and the range of a projectile may be thus increased to a distance perhaps never contemplated.

As the elastic gas, therefore, is the projectile power of gunpowder, it is evident that if we allow any of it to escape without acting upon the projectile we lose so much power. A great deal escapes through the vent or touch-hole, and a great deal more is lost from the windage, or the difference of the diameter of the bore and the shot; which, if a shot fitted as a tight as a piston in a cylinder, would not be the case.

To remedy the loss by windage is an easy matter; it is accomplished by an expanding shot or bottom, but the remedy of the loss by the vent requires consideration. It has been found by experiment that gunpowder does not ignite so quickly in a close chamber without a slight communication with external air, as when that is the case; and thus it has been found that with the Prussian needle gun a small chamber containing air in the vicinity of the charge was necessary to ensure the perfect ignition of the charge. The ingenious Captain Norton, who proposes to fire cannon without vents, by means of a friction igniting apparatus, may perhaps not be aware of this circumstance; but experiments have been tried years ago with various sized vents, and when reduced to the minimum, a decrease of range was experienced. It is evident that directly a sufficient power is formed by the inflammation of the charge to move the shot forward, it will begin to move; the quick ignition of the whole charge before the shot quits the muzzle is, therefore, of the greatest importance. I

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Miscellaneous.

Lieut. Colonel Parlby on the Flight of Projectiles.

Fig. 1.

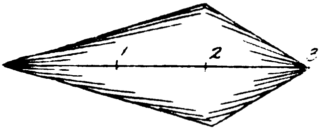


Fig. 2

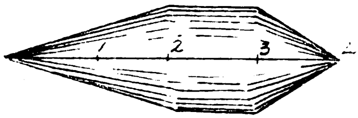


Fig. 5.

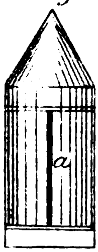


Fig. 4.

Fig. 3.

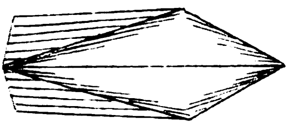


Fig. 6.

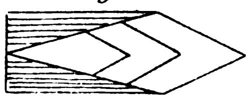


Fig. 7.

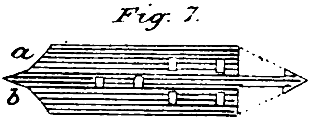
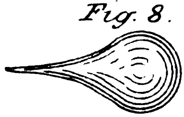


Fig. 8.



Madras Arty Depôt N. S. W. P. E.

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find my paper has already, perhaps, exceeded the space you can allow. I must, therefore, reserve the notice of the rifle and some other matters to your next.

I am, Sir, yours, &c.,
SAMUEL PARLBY.*

Lieut.-Colonel Parlby on the flight of Projectiles.

To the Editor of the Mechanic's Magazine.

Sir,—The origin of the rifle—the inventor's name—even the country he belonged to—is, I believe, unknown; but the general impression in England is that the Germans first adopted rifles in Europe. The want of written or verbal record leaves us at a loss to determine upon what principle the first inventor of the rifle acted. No doubt it was found that round balls from smooth barrels were deflected in uncertain quantities from the true aim, and an inventive mind, observing that the feathered arrow (the earliest weapon), from its rotation round an axis parallel to the line of flight, kept a direct course, may have proceeded to try the same experiment with balls fired from barrels and propelled by gunpowder, without having then considered the fact that the principal cause of the deflection of the round ball was the unequal resistance the fore part of the shot met with in its passage through the air, from its rotating round an axis perpendicular to the plane of flight; which rotation is caused by the rolling of the ball or its striking against the internal surface of the bore as it passes along; and thus a round ball is variously deflected—upwards, downwards, right and left, horizontally or obliquely—according to the direction of the axis of rotation, the deflection being towards the side where there is the least resistance.

But another observation may have led to the invention of the rifle. Gunpowder, in former years, was not so strong or so quick of ignition as at the present day; and, therefore, the ingenious inventor of the rifle may have thought that by de-

* Mechanic's Magazine 11th August 1855.

laying the passage of the shot a little in the barrel, by causing the spiral motion, the powder of a large charge being more fully inflamed would act with greater force upon the ball to give its full velocity proportionate to the charge, and the result of a more extended range would be the consequence of powder of slow ignition.

It is well known to those who are accustomed to fire-arms, that the rifle differs from the smooth barrel in having grooves or furrows cut in the interior of the cylinder, which, taking a spiral curve, cause the ball to rotate with an axis of rotation similar to that of an arrow, but *more violently*, the grooves making one turn in the small length of from 2½ to 4 feet; and I conceive this is one of the great errors in forming rifles—one turn in 100 feet would be better.

It would be useless to attempt to describe the variety of rifles. In some the grooves were deep, in others shallow; sometimes numerous, at others reduced to 2. In some the ball was forced down with a strong ramrod assisted by a hammer; in others the balls being cast rather larger than the cylindrical part of the bore, were loaded at the breech and forced through the spirals by the pressure of the exploding charge; in others again balls were used with projections upon them fitting into the grooves; in others the round ball was covered with a piece of greased leather, and then forced into the barrel in loading, the leather fitting into the grooves and giving the necessary rotation to the ball; and now are used shot formed so to expand at the end next the charge, and press into the grooves as they are driven through the barrel, as in the case of Minié, or, truly speaking, Captain Norton's ball. Another of Captain Norton's plans is using an expanding sabot or bottom to the shot. The object of all these is to give a proper rotation to the ball as it passes through the air, round an axis coinciding with the line of flight.

The great object with cannon or fire arms is to obtain the longest range with as little elevation as possible; and to ob-

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tain this, of course it is desirable to give the greatest possible velocity to the shot with a certain charge.

A few years ago, a Mr. Lovel proposed a two grooved rifle, for which a ball was used having a projecting belt around it, which fitted into the grooves; and I shall particularly allude to this because it is the principle which has been taken by Mr. Lancaster in his celebrated guns, only in a much improved form. It was found on trials with Mr. Lovel's balls that they made a considerable whistle or noise in the air in the first part of their flight, but that the resistance of the air was so great, in consequence of the projecting band, that at 700 yards they were excelled in range, with the same charge of powder, by round balls well fitted to smooth barrels; the latter ranging, at the same elevation, to 800 yards. It was also found that, at about 350 yards, the whistling almost ceased, and the balls ceased to rotate, and that, on striking the ground, they hit on the half sphere, shewing that they had changed their horizontal axis to a perpendicular one.

It was also found that the sediment from the inflamed powder rendered it difficult, if not impossible, to ram down the well-fitting balls after 20 or 30 rounds; and in some instances part of the belt was driven off in passing through the grooves of the barrel. Now Mr. Lancaster has proceeded differently in some degree. He casts his cannon, or bores them, with two very shallow spiral incurvations in the interior of the bore, so that the bore is slightly oval; and the shot are elongated and ingeniously formed, some of cast, some of malleable iron, so as accurately to fit the bore. But when the enormous size of these guns is considered—10 inches bore!—and the weight of a shot of this shape and size, which is to be propelled with such velocity that a range of 4000 to 5000 yards is obtained; also that there is the danger of the fracture of his cast-iron shells, as well as the change of form and wedging in the bore of those of malleable iron, it is

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hardly possible to suppose that cast-iron, the metal his guns are made of, can sustain the shock of the discharge. In fact, a great number of them have become unserviceable from having burst, the fracture generally having taken place in the chase, about 2 feet from the muzzle, showing that it is not the explosion of the powder, but the violent strain and shock of the oval shells, that burst the guns.

Now, granting that by using rifled guns, and even cannon of moderate size, we obtain the advantage of a more correct aim than with smooth bores for a certain distance, it is certain that the rifled ball, towards the end of its range, is very uncertain; for directly the rifle rotation of the ball ceases, its irregularity of form, either if there are projections cast upon it, or from those it receives at its tail end, if an expanding shot, causes great deviations from the true plane of range. Robins found that the velocity of a rifled ball was less than that of a bullet fired from a smooth barrel with the same proportions of powder, and that its range was also less, and that when he tried a leaden ball of half an ounce at 12° elevation with one drachm of powder, the bullet ranged pretty well for 550 yards; but when he fired a similar ball at 24°, it ranged very irregularly, generally diverging from the line of direction to the left, and in one trial not less than 100 yards, the revolving motion being to the right.

It was also found that another cause of irregularity of flight in balls fired from rifles, was the great quantity of friction in the barrel, and the impossibility of rendering it equal in each experiment; so the velocities of rifle balls differ much more than those from a common smooth bore.

Whatever, therefore, tends to make the friction equal, and to lessen it, will increase the range, for it is certain, that the easier the bullet moves in the piece, supposing it not to shift its true position in the axis of the bore, the greater the accuracy and velocity of the flight will be.

We may well, therefore, ask whence are derived the accu-

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racy and the length of range of the Minié rifle and the Lancaster gun. In the first, we are to recollect that the Minié ball weighs nearly one half more than a round ball of the same diameter; hence it has much greater momentum than the latter to overcome the resistance of the air. Again, it is an expanding ball, totally preventing all loss of the propelling power by windage, as its expanding part next the charge completely fills up the section of the cylinder of the bore. The Lancaster shot and shells are also accurately fitted, and being of an elongated form are of greater weight than a spherical shot or shell of the same diameter; but if the weight of these balls was reduced to that of a round ball of the same diameter, with proper applications to prevent the loss by windage, and to keep the shot steady in the barrel, the shot from the smooth bore would have the advantage in certainty and extent of range.

I am, Sir, yours, &c.,

SAMUEL PARLBY.

P. S.—If your correspondent, Mr. George Hunter, of Leysmill, will be kind enough to attend to my description, he will find that I particularly dwell upon the necessity of keeping the centre of gravity in the middle of the shot; and thus the head would not be heavier than the tail. The softness of the lead, and its compression by the force of the exploding charge, are effectually guarded against by the shape of the bottom, and by making the middle of the shot from point to point, as well as the wings, of steel or malleable iron; and if Mr. Hunter will take a small rod of steel, and form it as shown in fig. 7, (Plate 31) he will avoid the defects he complains of. The dark part represents the piece of steel or malleable iron the length of the shot, and flattened out at the tail end to form the wings; these are of course to be bent to the right and left at *a* and *b*, so as to cause each wing to form a small angle of about ¼ of a degree with the axis of the shot. The dotted lines are the outline of the cast iron

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or lead to be cast upon it when laid in the mould; the holes are to secure the sides by the metal running through them. Probably another mistake he may have committed, was giving too rapid a rotation, by making the angle of the wings with the axis of the shot too great; ¼ of a degree is quite sufficient. S. P.*

Projectiles.

To the Editor of the Mechanic's Magazine.

Sir,—I have read with much pleasure Colonel Parlby on the flight of projectiles, but I cannot believe that he has come to a correct conclusisn with regard to the proper shape of a projectile (something like a fish) to ensure a direct flight. There is, in my opinion, a great difference between a body of that shape being projected by the fins of a living fish, which are in constant motion, bending or resisting the medium through which the body passed, and a somewhat similarly shaped dead body projected through a tube by means of gunpowder, which only exerts its power for an instant; besides which, the wings of the projectile are immoveable, and cannot therefore correct its flight, providing it does not leave the muzzle of the gun in a straight line. Moreover, it appears to me that no projectile would be more likely to deviate from a direct line than the one recommended by the Colonel. If it leave the mouth of the gun with the least possible departure from a right line, how great will that deviation not be before it has reached 300 yards? Now, if we follow nature's plan in something analogous to a projectile, and consider the shape which the swiftest bodies assume in traversing the heavens, we find them of a round form. I have often thought, though I may be wrong, that if a bullet were shaped thus, fig. 8 (Plate 31) it would be a projectile least liable to deviate from a straight line.

I am, Sir, yours, &c.,

London, August 20, 1855. J. J. LOCKHART.†

* Mechanic's Magazine, 18th August 1855.

† Mechanic's Magazine, 25th August 1855.

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The Long Range and Vertical Fire.

To the Editor of the Mechanic's Magazine.

Sir,—You are doubtless well aware that our improvements and discoveries depend more on our perseverance and the exercise of common sense than on theories; and that the antiquated notions which are inseparably connected with the latter, tend more to retard than to aid the progress of practical science. It is a fact well known to practical men, that the angle for the greatest range is 45°, and that shells, when thrown at this angle, drop vertically on approaceing the horizon. Yet this fact is not recognized by our mathematicians, and they still obstinately maintain and propagate in their works on projectiles, that "when a body is projected obliquely upwards," say "at an angle of 45°, its descent is not towards the earth's centre, but inclined to the earth's surface *at the same angle it was projected.*" Is it not too bad that such a doctrine should be taught to the officers of our artillery? This most unaccountable idea that bodies projected, move in curves, and drop at the same angle, is maintained also in Herschel's Outlines of Astronomy. See Hopkins' Geology and Magnetism, 2d edition, page 176. I should like to know the opinion of some of your correspondents on this apparent misconception.

I am, Sir, yours, &c.,

London, July 24, 1855. A Civil Engineer.

[We subjoin the passage of Mr. Hopkins' work, referred to by our correspondent.]

"When a ball is discharged, it is not the mere resistance of the air and the earth's attraction that reduces the velocity and brings it into a state of rest; it is the *evanescent quality* of that power which had put it in motion: the resisting medium and the attraction of the earth only *diminish the extent* of its path. According to the doctrine of gravitation, neither the radial attraction of the planets, nor a resisting medium, has any influence on the impulsive effect: on the contrary, it

is made both *continuous and uniform*, an effect totally inconsistent with the known principles of physics. Had such a doctrine of the laws of motion been founded on correct data, we should have no difficulty in effecting a perpetual motion. What an amount of ingenuity, labour, and expense have been thrown away on the pursuit of the perpetual motion, which might have been turned to better use, if the simplest laws of terrestrial physics had been consulted instead of mere geometry; that is, that no motion can take place and continue without the presence of an active principle!" * *

"The following extract from a standard work on astronomy, written by one of the first philosophers of the day, will at once show on what foundation the orbital motions of the 'Principia' are based, and how geometrical curves and the paths of projectiles have been confounded.

"'All bodies with which we are acquainted, when raised into the air and quietly abandoned, descend to the earth's surface in lines perpendicular to it. They are therefore urged thereto by a force or effort, which we term *gravity*, and whose tendency or direction, as universal experience teaches, is towards the earth's centre; or rather, to speak strictly, with reference to its spheroidal figure, perpendicular to the surface of still water. But if we cast a body obliquely into the air, this tendency, though not extinguished or diminished, is materially modified in its ultimate effect. The upward impetus we give the stone is, it is true, after a time destroyed, and a downward one communicated to it, which ultimately brings it to the surface, where it is opposed in its further progress and brought to rest. But all the while it has been continually deflected or bent aside from its rectilinear progress, and made to describe a curved line concave to the earth's centre, and having a *highest point*, *vertex*, or *apogee*, just as the moon has in its orbit, where the direction of its motion is perpendicular to the radius. When the stone which we fling obliquely upwards meets and is stopped in its descent by the earth's surface, its motion is not towards the centre,

but inclined to the earth's radius *at the same angle as when it quitted our hand.* As we are sure that, if not stopped by the resistance of the earth, it would continue to descend, and that *obliquely*, what presumption, we may ask, is there that it would ever reach the centre, to which its motion, in no part of its visible course, was ever directed?

"'What reason have we to believe that it might not rather circulate round it, as the moon does round the earth, returning again to the point it set out from, after completing an elliptic orbit, of which the centre occupies the lower focus? And if so, is it not reasonable to imagine that the same force deflects the *moon* at every instant from the tangent of her orbit, and keeps her in the elliptic path, &c.? . . . . It is on such argument that Newton is understood to have rested his law of gravitation.'*

"If a body thrown up at a certain angle; say 45°, will descend again at an angle of 45°, it follows that if thrown sufficiently high it would escape the earth altogether, and possibly revolve round it: but what is the *fact?* It is, that bodies *do not* return at the *same angle.* Suppose a stone was thrown up at an angle of 45° with a force which would carry it to an elevation of 500 yards, it would on its near approach to the earth descend almost *perpendicular.* It commences with its maximum angular force, which exceeds that of the radial attraction of the earth proportionably to the sides of the parallelogram of which its path is a compound; at its greatest elevation the radial attraction and the impulsive force are in a state of equilibrium; as the latter rapidly decays, the former being constant and accumulating, the stone returns, and the angular or tangential force becomes evanescent, until at length the stone is left to the sole action of the radial attraction of the earth, and therefore must proceed towards the centre. Those who may not feel disposed to prove the above mathematically, or who may prefer hav-

* Herschel's "Astronomy."

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ing an ocular demonstration of the fact, may have an illustration in the path of a stream of water forced by a strong pump at a given angle, when it will be observed that the curve of the stream of water, instead of forming the same angle at each extremity, will be very different. The impulsive force will be exhausted at A and B. (Fig. 1.)

Fig 1

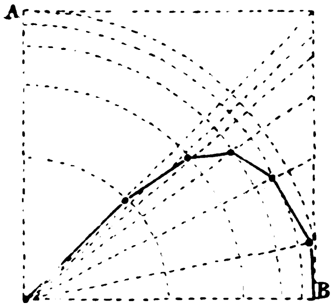
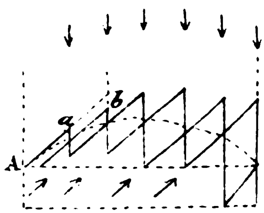


Fig: 2



" To suppose that the moon is retained in a circular path round the earth by a *projectile force*, is contrary to analogy, and cannot be demonstrated.

" The parallelograms commonly described of the composition of the projectile and gravitating forces, are very erroneous; and it is somewhat surprising that they have not been long ere this corrected. A projectile force can neither be constant in direction nor uniform in velocity throughout the curve described. According to the *theory of projectiles* taught in schools, it is supposed that 'if a cannon ball be shot from A in the direction A *b* (Fig. 2) (described above), and its original velocity be such as would carry it through the space A *a* during one second, then, if not subject to gravity, it would proceed in a straight line and arrive at *a* in one second, at *b* in two seconds, and so on. Gravity would cause it, during the first second, to fall sixteen feet, and by com-

pleting the parallelograms the following arc is described,' and by means of such assumptions, it is supposed 'that the ball moves in a curve and falls in the same angle as projected.'

"In the above parallelogram we can readily admit the parallelism in the vertical action of gravity, within the range of a cannon-ball, but we cannot conceive how a force emanating from the cannon's mouth, fixed to one point, and only capable of imparting that force at that point, could act in the oblique parallel lines shewn in the figure. In the vertical direction we find the space described by the ball gradually diminished, until at length the upward force is exhausted, and the ball brought back solely by gravity. Why should the projectile force be constant and uniform at an angle of 45°?"*

The Long Range and Vertical Fire.

To the Editor of the Mechanic's Magazine.

Sir,—I have some objections to offer to the matter of "Civil Engineer's" letter, which appeared in your last number. Perhaps you will not esteem them unworthy of a portion of your valuable space. He desires to place, what he terms "theories" and "antiquated notions" in antagonism with the progress of "improvement and discovery", and his attempts, like most such, serve only to show that he does not appreciate or understand the object of his attack. We have theories in the various branches of natural science, which are correct interpretations, of large classes of well ascertained facts. To prove that these are of some value and service in the progress of "discovery," I need only point to the discovery of the planet Neptune, by Mr. Adams; a discovery made by means of calculations founded on the very theories which "Civil Engineer" and Mr. Hopkins attack so readily

* Mechanic's Magazine, August 4th, 1855.

and so inconsiderately. The opening sentence of the letter is, in my humble opinion, wholly erroneous.

"It is a fact well known to practical men that the angle for the greatest range is 45°, and that shells, when thrown at this angle, drop vertically on approaching the horizon." This appears to me a very unfortunate statement to make in connection with what goes before. For supposing it to be the fact, that 45° is the angle of projection corresponding to the maximum range, the fact would be in favour of the theorist and not of "Civil Engineer;" 45° being the value of the angle for maximum range which is given by the theoretic investigation which "Civil Engineer" is so anxious to repudiate.

But, further: has your correspondent any real ground for his statement, that such is the actual elevation for greatest range? I suspect, for my own part, that the said statement is more remarkable for its boldness than for its correctness. There can be little doubt that, notwithstanding the supposed confident knowledge of practical engineers, and the late disquisitions of newspaper correspondents on the subject, that 45° is not the angle of projection proper to greatest range. It is certain that in vacuo this would be the value of the said angle, the path of the projectile then being parabolic. And it is almost certain, from the wide difference between such a path and the actual one, that the angles of maximum range in the real and in the imaginary case would not be identical. At any rate, "Civil Engineer" will not, perhaps, object to furnish your readers with some account of the experiments upon which his proposition rests. Whether, indeed, it has any other foundation than the authority of the mathematician who is so ungratefully treated by the men who are continually making his thoughts and labours their servants.

As to the shell dropping vertically as it approaches the horizon after having been projected at the above repeatedly mentioned angle, that is, *a priori* strictly untrue; the shell describes a curve whose descending branch has what mathe-

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maticians call a vertical asymptote, that is, the shell's path approaches continually nearer and nearer to a vertical straight line at a finite distance from the initial position of the shell; yet, however far its course be pursued, it never can be accurately vertical. That it should fall vertically as it approaches the horizon is, in simple terms, not even possible.

In the next sentence we have, "Yet this fact is not recognized by our mathematicians." This, too, is not true; for none knew so well as mathematicians, that they are unable to grapple successfully with the problem in its full conditions. This Herschel is careful to set forth in connection with the passage appended to the letter of "Civil Engineer." I will not trouble you with any notice of the extract from Mr Hopkins's work at present. I propose, with your permission, to say something regarding it another time.*

I am, Sir, yours &c.,

A Mechanic.

Long range and Vertical Fire.

To the Editor of the Mechanic's Magazine.

Sir,—I regret your correspondent, "A Mechanic," in reply to my remarks, has thought it proper to travel so far into the regions of darkness for the purpose of endeavouring to maintain that the *assumed theories* of mathematicians demand more respect than the *theories founded on every day observations and experiments.*

I am also somewhat surprised at his stating that the discovery of the planet Neptune was made by means of calculations founded on the theory that projectiles rise and fall in the same angles.

Mathematicians themselves confess, as he states in the same

* Mechanics Magazine 11th August 1855.

letter, "that they are unable to grapple successfully with the problem", not because of the difficulties it involves, but owing to their endeavouring to force the projectile into an arc, and to describe equal spaces in equal times—conditions which may suit *geometrical* curves, but are not applicable to, nor reconcilable with, the laws of *physics*. If your correspondent can assist the physico-mathematician in getting out of this dilemma, he will do a great deal of good; but, to effect this, he must obtain the *elements of the parallelograms*, compound and decompose them, according to the ordinary practical system adopted in the composition of forces, and not produce assumptions. Let him show how the objectionable parallelograms can be made consistently with the experimental facts. Practical experiments, and Mr. Hopkins' parallelogram of projectiles, show that the descent from the angles of 90° to 45° becomes vertical on their near approach to the horizon, and from this angle to zero the fall becomes more oblique, and the range diminished.

These are the results of experimental proofs, and *theory founded on practice*. Let your correspondent show us how the *mathematical theory* of equal angles at each extremity has been proved. If the projectile force becomes completely exhausted on the projectile being thrown up at ninety degrees, and returns only by the force of gravitation, why should it not exhaust itself at all other angles?

If bodies fall at the same angle as projected, can they fall at all when thrown horizontally?

I am, Sir, yours, &c.,

August 13, 1855. CIVIL ENGINEER.

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Remarks on Colonel P. Anstruther's Theory by Colonel J. W. Croggan.

To

The Director of the Artillery Depôt.

Sir,—I have the honor to request the favor of your publishing in the Madras Artillery Records the accompanying "Remarks" and "Diagram" on the subject of Colonel Anstruther's Theory of the Flight of Projectiles.

I have the honor to be,

Sir,

Your most obedient Servant,

J. W. Croggan, Lt. Col. (Colonel,)

Madras Artillery.

St. Thomas' Mount,
19*th May* 1858.

Flight of Projectiles.

I have derived much pleasure from the investigation of this subject, and although I do not fully concur in some of the arguments advanced, yet, I am of opinion that the method of applying different velocities, and deducing therefrom the elevation, range, and time of flight must be of utility to the science of projectiles; and I believe all that is required to perfect the system is a correct estimation of the retardation of the projectile, during its flight, from the resistance of the atmosphere.

It is to be regretted that the subject was not properly disposed of at home by the scientific Officers to whom it was referred for consideration; I will however endeavour to arrange the prominent features of it; and offer such explanation, and remarks, as the subject may seem to require;

being of opinion that every advance in science sho
most narrowly scrutinized.

The theory under review shews 25° 53′ to be the ele
required to give the greatest range; while in Hutton
thematics the elevation is stated to vary from 45°,
according to the velocity and weight of the projectile;
trust this simple question may soon be settled by actu
periment, as requested by Colonel Anstruther.

The Argument.

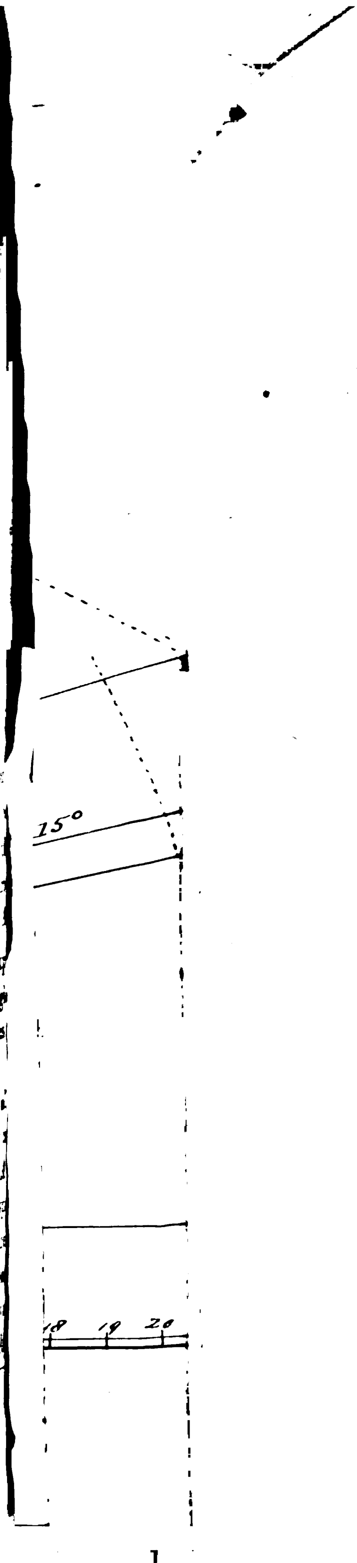
1. A ball falling from *Y* to *A* (vide diagram*) acq
certain velocity *V*. With that velocity a ball projected
A, will ascend to *Y*, and will describe equal spaces in
times, in rising and falling; but in an inverse order;
will have equal velocities at any one and the same p
the line described; both in ascending and descending
the increased velocity with which it ascends from *A*
destroyed by gravity until the ball arrives at *Y*.

2. At the same time that the ball is projected from
Y with the velocity *V*, another ball is supposed to be
horizontally from *A* to *X*, with an equal velocity: t
forces combined would, then, take the ball in the sam
from *A* to *G*; the line *AG* being equal to $AX\sqrt{2}$ or *A*

3. As this multiple, $\sqrt{2}$, may require exp
on, suppose c=the hypothenuse of a right angle
angle, and a, and b, the two other equal sides
$c=\sqrt{a^2+b^2},=\sqrt{2a^2},=a\sqrt{2}$.

4. The initial velocity in the direction *AG* is al
creased to $V\sqrt{2}$; and various results are obtained by m
any distance from *A*, passed over in the direction *A*
hypothenuse of a right angled triangle; the falling sp
the same time, the perpendicular; and the horizon
third side the range. In this manner the several spa
lines, *Aa*, *Ad*, *Ag*, *Ak*, *An*, and *AG*, are made to rev
the point *A* to *Ab*, *Ae*, *Ah*, *Al*, *Ao*, and *Ar*, respectivel

* Plate 32.



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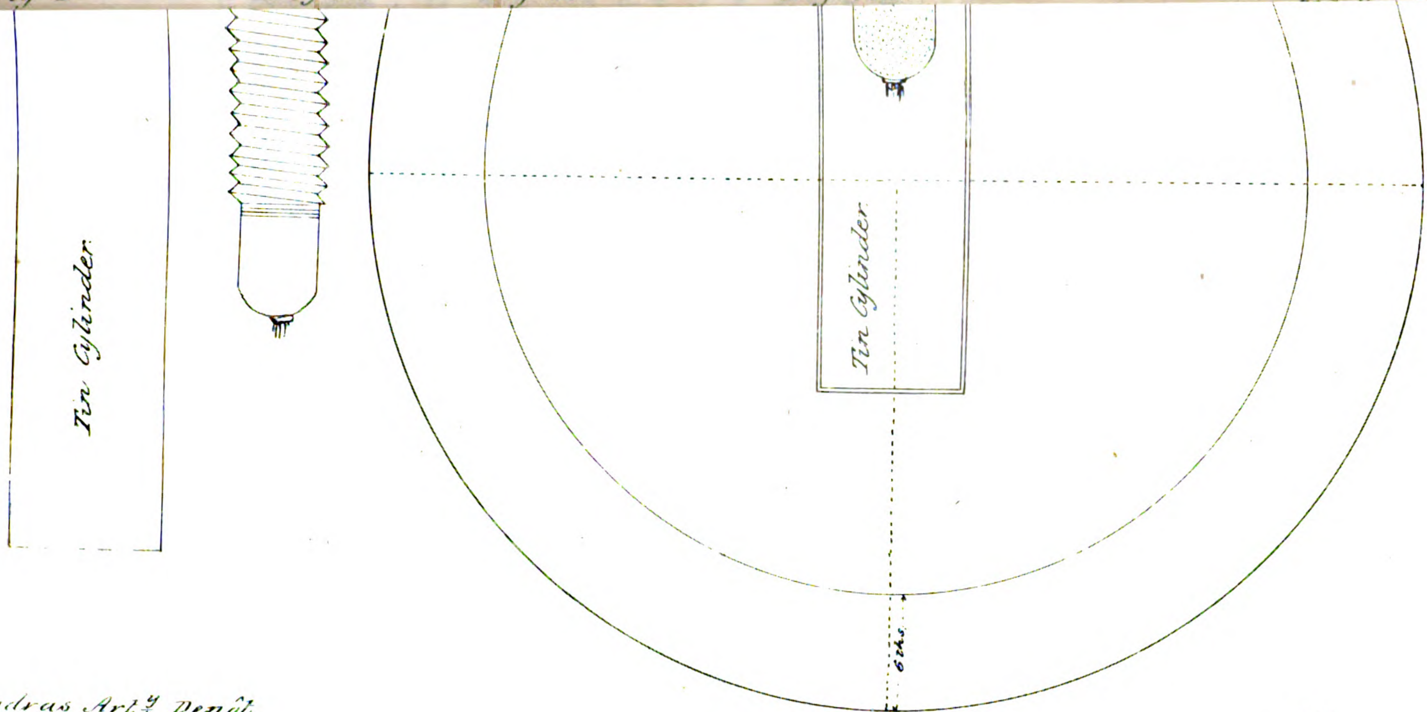
Page 387 **Miscellaneous.** Plate 33.

Fig: I. Fig: II. Fig: III. Fig: VIII.



Madras Art^y Depôt

J B

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angle of elevation, and range thus varying in each case, as follows:—

Flight Seconds.	Hypothenuse or diagonal space.	Perpendicular or vertical space of the falling body.	Elevation.	Horizontal space or range.
1	*Aa*, and *Ab*	*bc*	3° 41′	*Ac*
2	*Ad*, and *Ae*	*ef*	8° 8′	*Af*
3	*Ag*, and *Ah*	*hi*	13° 38′	*Ai*
4	*Ak*, and *Al*	*lm*	20° 42′	*Am*
5	*An*, and *Ao*	*op*	30° 20′	*Ap*
6	*AG*,	*GX*	45°	*AX*
7	*AG* and *Ar*	*rs*	71° 14′	*As*

5. The greatest range *Ap*, is here given at an elevation of 30° 20′ after which the range constantly diminishes. The initial velocity $V\sqrt{2}$ takes the body to *r*, and afterwards to *Z*, which being vertical gives no range; and the space *Z* to *A* is $36\sqrt{2}$ spaces, and time 7·135 seconds.

6. The actual distance fallen by a body in a given time, is the time squared multiplied by $16\frac{1}{12}$ feet, the space fallen by a body in one second; but $16\frac{1}{12}$ being a constant quantity is omitted in all these calculations, and the measurement is given in spaces of $16\frac{1}{12}$ feet each: for instance a body falls from *Y* to *A* in 6 seconds, the distance being $36 \times 16\frac{1}{12} = 579$ feet; or 36 spaces.

7. There was I consider no necessity to adopt a combination of forces, resulting in the diagonal line *AG*; as the several spaces on the original line *AY* would in like manner have formed the hypothenuses of right angled triangles, and have produced the results required; in fact the spaces on the line *AY* without the multiple $\sqrt{2}$ being affixed exhibit the true retardations of gravity.

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Flight Seconds.	Hypothenuse or vertical space.	Perpendicular or space fallen by a body in the same time.	Angle of elevation,		Horizontal side or range.
	Spaces.	Space.			Spaces.
1	$At=11=Au$	$uv=\ 1$	6°		$Av=10{\cdot}75$
2	$Aw=20=Ax$	$xy=\ 4$	11°	30′	$Ay=19{\cdot}75$
3	$Aa'=27=Ab'$	$b'c'=\ 9$	20°		$Ac'=25{\cdot}4$
4	$Ad'=32=Ae'$	$e'f'=16$	30°	15′	$Af'=27{\cdot}8$
5	$Ag'=35=Ah'$	$h'i'=25$	46°		$Ai'=24{\cdot}7$
6	$AY=36=Ak'$	$k'l'=30{\cdot}25$	57°	30′	$Al'=19{\cdot}65$

The elevation that gives the greatest range according to this method appears to be about 30° 15′ which more nearly coincides with the results given in Hutton's Mathematics, before quoted.

8. To apply the alteration suggested by me to an initial velocity of 2000 feet, let s=space, v=velocity, $g=16\frac{1}{12}$ feet; then,

$$AY \text{ or } s=\frac{v^2}{4g}=\frac{2000^2}{4\times 16\frac{1}{12}}=62189 \text{ feet}$$

$$t=\frac{2s}{v}=\frac{2\times 62189}{2000}=62{\cdot}19 \text{ seconds.}$$

Calculate the distances for a falling body from Y to A corresponding to 62·19 seconds; make the distance from A for each second, in succession, the hypothenuse of a right angled triangle, and ascertain the perpendicular, the horizontal side, or range, and the elevation, in the manner before described; and arrange the whole in a table for reference, as set forth in the treatise.

9. By Colonel Anstruther's proposed theory, the rules for the retardation of a body from the effects of gravitation when projected upwards, are applied to the flight of a ball when retarded by the resistance it meets with from the density of the atmosphere; but as the circumstances of the two are very different, I consider the same rules cannot apply to both; I would therefore suggest that the diagonal spaces be

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calculated by the known rules for the resistance of the atmosphere, and the perpendicular spaces only by those of gravity.

10. Passing over some minor passages throughout the treatise, I will proceed to examine the tabular statement of falling bodies from the effects of gravity, on which the calculations depend.

Descending.

seconds of time	1	2	3	4	5	6
spaces as the squares	$S\times 1$	4	9	16	25	36
space in each second	$S\times 1$	3	5	7	9	11
velocity acquired	$S\times 2$	4	6	8	10	12
ascending with the initial velocity $S\times 12$						
seconds of time	1	2	3	4	5	6
velocity	$S\times 12$	10	8	6	4	2
rising through	$S\times 11$	9	7	5	3	1
reaching to	$S\times 11$	20	27	32	35	36
or to 6^2 S, minus	$S\times 5^2$	4^2	3^2	2^2	1^2	0

with reference to the last two lines let the time of the falling body, viz. 6 seconds, giving the final velocity, V, ... $=t$

The time of flight of the body projected from A with the initial velocity V.................... $=x$

The space passed over by the projected body... $=s$

Then the space passed over in the direction AY......................... $=t^2-(t-x)^2=s$

$$\text{or}=t^2-(t^2-2\,tx+x^2)=s$$

$$\text{or}=2\,tx-x^2=s$$

This multiplied by $\sqrt{2}$ gives the corresponding distance in spaces on the hypothenuse AG.......... $=\sqrt{2(2\,tx-x^2)}$

The distance of a falling body during the same time, or the perpendicular of the right angled triangle $=x^2$

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The horizontal side of the triangle or the range, being the distance on the line AX......$=\sqrt{(\sqrt{2(2tx-x^2)})^2-x^4}$

This expression is capable of being reduced, but it agrees with the formula given in para. 10 of the treatise.

Then knowing two sides of the right angled triangle, to find the elevation

12 of the treatise.

The corresponding elevation being 25° 53′ which gives the greatest range.

Suppose the time of the falling body corresponding to the initial velocity $V.$ to be 44 seconds,

then $x=44\times{}^{\cdot}7639=33{\cdot}61$ and the elevation giving the greatest range 25° 53′ as before. (Vide Table D. of the treatise.)

12. To find the range corresponding to a given initial velocity, and elevation, say, 15°?

Let the time of the falling body corresponding to the initial velocity V,.. $=t$

The time of flight.. $=x$

The natural sine of 15°=·2588........................ $=a$

Radius or 90° =1 .... $=b$

ERRATA.

"Miscellaneous" page 586 seventh line from the bottom *for*

$$\frac{2^{\frac{3}{2}}t}{x}=\frac{1}{a}+2\tfrac{1}{2} \text{ read } \frac{2^{\frac{3}{2}}t}{x}=\frac{1}{a}+2^{\frac{1}{2}}$$

fifth line from the bottom *for*

$$\frac{1}{x}=\frac{1}{2{\cdot}828\times 6{\cdot}\times {\cdot}2588}+\frac{1{\cdot}414}{2{\cdot}82\times 6}=\frac{1}{3{\cdot}215}$$

read $$\frac{1}{x}=\frac{1}{2{\cdot}828\times 6{\cdot}\times 2588}+\frac{1{\cdot}414}{2{\cdot}828\times 6}=\frac{1}{3{\cdot}215}$$

$$\frac{1}{x}=\frac{1}{2{\cdot}828\times 6{\cdot}\times {\cdot}2588}+\frac{1{\cdot}414}{2{\cdot}82\times 6}=\frac{1}{3{\cdot}215}$$

$x=3{\cdot}215$, (vide Table in para. 16 of the treatise.)

Then $\frac{x^2}{a}=\frac{3215^2}{{\cdot}2588}=39{\cdot}93=AB$

As the angle *BDA* or radius	:	*AB*	::	Cosine of angle *BAD* 15°	:	*AD*, the range
1	:	39·93	::	·9659	:	38·57.

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$$39{\cdot}93 = 1{\cdot}601299$$
$$\cdot 9659 = \bar{1}{\cdot}984932$$
$$1{\cdot}586231$$
$$1 = 0{\cdot}000000$$
$$1{\cdot}586231 = 38{\cdot}57$$

spaces which agrees exactly with the result given in the table referred to.

13. I have attempted to solve these problems agreeably to the theory advanced, as the methods of making the calculations in the treatise appear to be very laborious; but, as I have before stated, to render the theory of practical utility the hypothenuse of the right angled triangle must be calculated by the rules for the resistance of the atmosphere without reference to those of gravity.

St. Thomas' Mount, 19*th May* 1858.

J. W. Croggan, Colonel, *Madras Artillery*.

Metal Fuzes suggested by Lieutenant H. D. Gloag, Madras Artillery.

Bellary 30*th November* 1857.

My dear Major,

I received the Table shewing the result of the trial of the Fuzes,* and forward a few suggestions that may remedy their failing, and which I hope you may consider worthy of notice.

Yours sincerely,

(Signed) H. D. Gloag.

I. The Fuzes have been a failure, 10 out of 15 of the solid head Fuzes not starting, and in practice all burning inaccurately except two.

II. The other description of Fuze is still more unsatisfactory 5 out of 8 not starting, one starting at the muzzle of the gun, and the composition of one only burning accurately. I am at a loss to account for the Fuzes burning correctly on the ground and not so in practice: from their burning with

* Page 620 Artillery Records head "Select Committee Proceedings".

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accuracy on the ground it would appear that the pewter has no effect in causing this inaccuracy.

III. The melting of the pewter is most fatal to its use, though it is readily fused, I was under the impression that it would have withstood the heat evolved by the ignited composition for some time longer than 7 seconds or 1 inch and 4 tenths of composition.

IV. To obviate the most serious objection, viz the melting of the pewter, I would propose that a thin tube of brass, copper or other less fusible metal than pewter, be placed on the iron core of the mould (as shewn by the yellow color fig. III, Plate 33) and that the pewter be run into the mould over the tube : no alteration is required in the mould.

V. I am inclined to think that many of the solid Head Fuzes never were ignited, the priming merely burning, this may perhaps be attributed to the priming only surrounding the part containing the composition, and not being in actual contact with it as in the wooden fuze now used, also in unscrewing the fuze in order to set it to any particular length, as well as in the sawing, and ramming home some portion of the priming may fall out, to remedy this I would propose, that a piece of cotton wick be soaked in saltpetre or some way be made highly inflammable, and one side of it, to have long shreds hanging from it, and that it should be cemented to the interior of the Fuze hole of the shell above the bouch (see fig. IV. *a. a.*) having the rough or hairy side inwards, and that after cutting off the upper portion of the Fuze not required, these long shreds (attached to the cotton wick cemented to the side of the fuze hole of shell) should be well stirred up, and brought over and placed in contact with the Fuze composition : the mealed powder &c. will adhere to these shreds and be less liable to be shaken out in preparing and ramming home the shell.

VI. To insure the bursting powder being fired, a small bag made of cloth soaked in saltpetre or in some way made

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to be screwed on the part projecting above the zinc bouch after the head has been sawn off and the Fuze adjusted to proper length; a view of a cap fixed and Fuze set to 4ths is given in fig. VII, the cap projects above the surface of the shell; these caps are carried separate in the limbers; if these caps were used, the Fuze might be made of the form fig. VI *a. a.* the head having a notch in top or hole through it, for the purpose of screwing it down tight upon the bouch; the head when the Fuze is fixed in the shell does not project above the surface of the shell; so can receive no injury in the limber, I should say it would be impossible to fire the bursting charge in shell, when this Fuze is screwed home.

IX. As I can see no reason for the solid head Fuzes not starting, except the priming being inefficient; and as a cap such as described above requires some trouble in making besides more metal; perhaps the following method of preparing the shell would insure the ignition of the Fuze composition; and it entails no extra trouble, or any alteration in the mould when the Fuze is being unscrewed for the purpose of setting it to the required length, I would suggest that one tenth more be unscrewed than is necessary and after the upper part has been sawn off, a notch be cut with the saw about one tenth in depth across the fuze (see *n.* fig. VIII) and by means of this notch the fuze be screwed a little way home, and that the shreds attached to shell as described in para V. be well drawn over the composition see fig. VIII. The small bag tied to the bottom of the Fuze, may be made long enough to contain the starting powder: with S. C. Shot in practice firing, the canister should be omitted, the necessary quantity of sand introduced and the fuze with bag attached containing starting powder screwed into the bouch.

X. A method of fixing the canister is represented at fig. IX. *b. b.* being the bouch, *a. a. a.* strips of tin forming part of the piece used to construct the cylinder, there are 4 strips three seen in the fig, these strips are adjusted as represented

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in the sketch, and then the bouch being inserted into fuze hole of shell is driven home with the iron setter.

XI. The reason for using Pewter, is that it runs better in the mould than other metals, and with a brass or copper tube introduced into the interior of a Pewter fuze, one of any length might be burnt without any danger of the Pewter melting, a brass, copper, or gun metal fuze, could not I imagine be run in a mould with a screw on its exterior, as the Pewter one can: simplicity is a great object and I think that nothing can be more simple in construction &c. than this solid head Pewter Fuze with a tube as described running up its interior.

The composition may burn accurately when in contact with the brass or copper of which the tube is made.

HENRY DUNDAS GLOAG, Lieutenant,
Madras Artillery.

Proposed method of separating the bursting powder from the bullets in Spherical Case Shot by Lieutenant H. D. Gloag.

Bellary, 22d January 1858.

MY DEAR MAJOR ROWLANDSON,

I send you something more about fuzes and will be glad if any part meets with your approval; if I succeed in suggesting any improvement, I shall be much pleased.

Yours sincerely,

H. D. GLOAG.

The following is a description of a method proposed for separating the bursting powder from the bullets in a spherical case without any alteration being made in the shell; the bursting powder consists of 14 drs. rifle powder as used in the Royal Artillery.

Plate 34 fig. V. *W*, is a section of a wooden former on the upper part of which a tin tube represented by the double lines *a.a.* and *b.b.* is placed, the whole is then covered with

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leather, (except the bottom or end *f,m*) by two pieces of sheep skin stitched down the sides *d,e,f.* and *h.g.m.* the tin tube and leather are removed from the former, and a circular bottom piece sewn on; a string is attached at the mouth *d.h.* see shell I, the lower part of the bag thus formed can be compressed and entered at the fuze-hole of the shell; after the bag has been passed into the shell, the part *e.g.f.m.* is to be filled with fine sand, in order to cause the bag to assume and retain its proper form, it is then lowered into the shell by the string and held by it in an upright position; see shell II; the bullets are then put in (see *B* shell II) to the number of 31; when putting in the bullets the shell will require an occasional shake, care been taken not to let go the string; now a stick *S*, look at shell III is entered into the tube in the neck of the bag, and held in an upright position in the centre of the fuze-hole of the shell, the string attached at the mouth *d.h.* can now be cut off; melted resin is to be poured into the shell till it is full; when the resin cools the stick must be removed, by chipping away all the resin above it and clearing the fuze-hole of the shell; the bouche with tin tube fixed to it fig. VIII (and which tube is made to fit exactly into that in the bag) is to be inserted into the fuze-hole of shell, the end of the tube attached being carefully entered into the neck of the bag; the bouche can be driven home with an iron setter, the sand shaken out, powder substituted: the resin prevents the bullets moving, and hardening round the bag full of sand; when the sand is removed the bag will not lose its shape.

Plate 35 shell I is a section of a 9 pdr. spherical case with the bursting powder separated from the bullets as above described; the shell has a fuze set in it, of the following description.

The shell is furnished with a leaden or zinc bouche *b.b* driven into the fuze-hole of shell with a carefully made iron setter; fig. 1 is a section of the fuze, 2 and 3 elevations

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giving views of the opposite sides; the fuze is to be made of lead hardened with zinc or antimony, and formed in a brass mould, having an iron core which forms the cup and hollow for the composition; the cup of the fuze is closed with a brass cap *b*, see the shaded part in the section figure 1, this cap has a groove round its upper portion for the purpose of attaching a string *s* fig. 3; the upper part of the fuze containing the cup is wedge shaped, and requires a few blows on the cap to send it home into the bouche flush with its top, see shell I; by means of the string *s* the brass cap can be removed; the cap will do for another fuze: by examining section fig. 1, it will be seen that the brass cap entering the cup of the fuze prevents the cup being destroyed in driving the fuze into the bouche; after driving the composition, a small hole *h* is to be bored down its centre, to insure the ignition of the fuze (recommended by Captain Boxer) by exposing a greater surface of composition to the fire of the ignited priming, some of which descends into the hole *h*, in placing the quick match and priming in the cup, room must be left for the brass cap which should be gently driven into the cup. To set this fuze to any required length an awl and piece of quick match are necessary, the awl must be large enough to make a hole that will admit a strand of quick match.

The graduating of the fuze is represented in figs. 2 and 3; there are two grooves down the sides of the fuze *c.d.* and *e.f* shaded in the section, and represented at *g.g.* in the cross section of the tube of the fuze under fig. 2, these grooves are formed by projections in the mould.

Counting from *a*, the shoulder of the fuze fig. 2, there is a puncture at every $\frac{1}{10}$ of an inch, in the groove, the first puncture being 2ths. from the shoulder where the composition begins; on the opposite side of the fuze and in the other groove there is also a row of punctures, the first puncture being $2\frac{1}{2}$ tenths from the shoulder *a*, see fig. 3, and between the others there is $\frac{1}{10}$ of an inch, so we have $2\frac{1}{2}$, $3\frac{1}{2}$, $4\frac{1}{2}$, and

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$5\frac{1}{2}$ &c. the punctures are shown in the section, the one row giving tenths viz. *e.f.* the other *c.d* giving $\frac{1}{2}$ tenths; the punctures might be numbered by having the figures printed on strips of paper or parchment and cemented down the sides of the grooves; but figures are not necessary, as there is little fear of mistaking the rows of punctures, the first puncture in the row *c.d.* giving $\frac{1}{2}$ tenths being farther from the shoulder *a* than the first in *e.f.* giving tenths, or some distinguishing marks might be put on the shoulder at the head of each row; on the side giving $9\frac{1}{2}$ tenths; $\frac{1}{2}$ might be marked, and on the other I. and down the sides at every fifth puncture a mark might also be placed; to set the fuze to any required length, say $7\frac{1}{2}$ tenths, in the second puncture below the mark denoting $5\frac{1}{2}$ enter the point of the awl and bore a hole straight through the fuze, and pass a piece of quick match allowing an end to hang down on each side in the grooves, then drive the fuze into the bouche by a few blows on the cap; the grooves are to contain the quick match, and prevent it from touching the bouche when inserting the fuze, there is also a less thickness of metal to bore through, see the section. Shell I has the fuze set at 4 tenths, if the shell be turned with the fuze downwards before loading, some of the powder will run up round the fuze and may adhere about the quick match.

Figs. 4 and 6 are fuzes of wood, with a brass cap similar to that just described, the shell must be fitted with a bouche to receive them; Plate 34 fig. VI, represents a fuze such as 4 Plate 35 set to 4ths, a notch *c* is cut half across the fuze immediately below the mark indicating the required length, a strand of quick match is introduced, see *m*, an end hanging down on each side of the fuze; the fuze is then driven into the bouche with a few taps on the cap. Shell IV Plate 34 is furnished with a wooden fuze, without a brass cap; being merely capped as the present fuze, it is set by boring a hole across the fuze and introducing a piece of quick match *m.m*; the cup is liable to split in driving the fuze into the bouche;

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which is not likely to happen if a brass cap were used as seen in fig. 4. Plate 35 fig. 6 is an elevation and 5 a section of a wooden fuze, thicker than fig. 4; it has grooves similar to the leaden fuze 3 and is graduated in the same way and is to be set in a similar manner, or it may have a notch sawn across it as fig. VI Plate 34, a strand of quick match introduced and the ends laid in the grooves *c.d.* and *e.f.* fig. 5 Plate 35, so that they may not be in the way when entering the fuze into the bouche; in firing shells for practice, the necessary quantity of sand should be put into the shell, and a leather or cloth bag of sufficient size to hold the starting powder, and admit the whole fuze might be attached to the lower end of the bouche before driving it into the shell. Shells for service prepared as described in page 592. Plate 35 fig. 7 is a plug covered with leather to be put in the bouche, till the shell is required.

Plate 36 is descriptive of a mould of brass for forming the fuze figs. 2 and 3 Plate 35; the fuze is to be graduated and entirely finished in the mould, with the exception of the marks denoting the 5th and 10th punctures &c. at the sides of the grooves see figs. 2 and 3 Plate 35.

Fig. 1 is a plan of half of a mould for forming the fuze without the grooves down the sides &c. fig. 2 shews both halves of the mould one half *a,b q, l,* and the other *a,b,k,g*; in each half of the mould a notch is made to receive pieces of metal *c,d.* and *e,f.* fig. 3 *g.n.* represents the notch in one half of the mould, fig. 5 shews a side view *c.d.* also *x.c.d.* a rear view of one piece of metal, fig. 6 the same of the other piece of metal *e.f*: similar parts in the different figures are represented by the same letters; in fig. 2 two rows of small nails are represented, those in the part *e.f*, $\frac{1}{10}$ of an inch apart from centre to centre, and those in *cd* correspond to the punctures shewn in fig. 3 Plate 35 which punctures they form in the groove down the side of the fuze, the nails are screwed into the parts *c,d* and *e.f*; the pieces of metal *c.d.* and *e.f.* project

into the mould and form the grooves down the fuze; which will be perceived by examining fig. 2 and fig. 7, the plan of end of the mould *t.g*; the parts *c.d.* and *e.f.* are fixed by screw nails at *m* and *n* also at *x*,*y* see figs. 2, 5 and 6.

I do not know what proportion of hardening substance should be mixed with the lead; the interior of the tube of the fuze should be free from indentations; and grease, "as grease increases the time of burning" Captain Boxer; I inserted a bag into a 9 pdr. S. C. as described in page 592 and succeeded in putting 31 bullets into the shell; these fuzes will be easier moulded having no screw, a wooden fuze such as fig. VI Plate 34 could easily be made, or one with a brass cap such as fig. 4 Plate 35, and set by sawing a notch across it; the saw must be thicker than those now used, so as to make a notch sufficiently wide to admit the quick match; the graduating part of the mould will be a little troublesome to make, but is not beyond the ability of a good maistry, "great advantage gained to the service by the adoption of the principle of separating the powder from the balls in the shell and of boring a small hole in the head of the fuze composition" Artillery Records page 25 February 1857 Captain Boxer's fuzes. I do not know how many bullets are contained in the Royal Artillery S. C. but the number must be considerably less than 41; the Royal Artillery have made great alterations in their S. C. shells; I have endeavoured to suggest a plan of separating the powder from the bullets without any alteration in the shell; I imagine a leaden bouche would be better than a zinc one with a wooden fuze; the wedge shaped part of the fuze must be a very little larger than the iron setter for driving the bouche.

HENRY D. GLOAG, Lieut.,
Madras Artillery.

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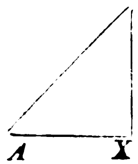
Flight of Projectiles by Colonel P. Anstruther C. B.



SUPPLEMENT.

Having reconsidered the subject,* I offer the following shorter statement of this argument.

Given—The range at any elevation.

Required—The Initial Velocity.

In a right angled triangle AGX, let AX be the given range, stated in spaces of $16\frac{1}{12}$ feet, S, and let the angle GAX be the given elevation.

Find AG and GX. Then

The square root of GX is the time of flight, T. Divide AG by the square root of 2; the quotient is the sum of all the terms, in an arithmetical progression, of which the time of flight is the number of terms, and 2 is the common difference. Find the greater extreme and multiply it by $16\frac{1}{12}\sqrt{2}$ for the

INITIAL VELOCITY

EXAMPLE.

A shot ranged 3359 yards at 15° required its initial velocity. Here, 3359 yards$=626{\cdot}55\ S=AX$, and $GX=167{\cdot}88$, the square root of which is 12·957, the time of flight of the shot, and the number of terms in our arithmetical progression.

AG is 648·65 S, and 648·65 is equal to $458{\cdot}666\sqrt{2}$ the sum of all the terms, which, divided by the number of terms, is 35·3991, and double this is the sum of the extremes 70·7982. The difference of the extremes is double the number of terms, or 25·914; therefore, the greater extreme is 48·356, which, multiplied by $16\frac{1}{12}\sqrt{2}$, gives 1100 the velocity.

P. ANSTRUTHER, Colonel, *Madras Artillery.*

1. CHAPEL STREET, GROSVENOR PLACE, *5th April* 1858.

* Page 534 Artillery Records.

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ARTILLERY EQUIPMENT

PRESENTED BY THE QUEEN OF ENGLAND

TO THE EMPEROR NAPOLEON

(Translated from the *Moniteur de l'Armee* of April 6th.)

We believe we shall be affording pleasure to our military readers, by giving them a brief description of this equipment, the services of which our army in the East were able to appreciate during the campaign in the Crimea.

It is composed of a gun, of a gun carriage, and of a waggon, with their limbers, of the materials which form the stores of the piece, of the side arms and implements requisite to serve it; and finally of the harness for a set of six horses.

The gun is of brass, its calibre is 4·2 in.; the ball, which weighs nine English pounds, corresponds, nearly, in diameter and weight, to the ball of a French 8-pounder. The shape of this weapon much resembles that of French guns; it however, has no dolphins.

The brass is perfectly homogeneous, and, notwithstanding the finish of the workmanship, which is very remarkable, not the slightest flaw in the casting can be perceived.

The upper surface of the piece is ornamented with much taste.

The first reinforce carries, as we have already said, the escutcheon of the Arms of France, surmounted by the inscription in Gothic characters.

TO NAPOLEON III,

FROM QUEEN VICTORIA

MDCCCLVIII.

On the second reinforce is the cipher "V. R." of the Queen of Great Britain, with the consecrated motto "Dieu et mon droit." Finally the chase is embellished with the

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initial of Lord Panmure, late Minister of War, surrounded by a riband, on which are inscribed the words "Nemo me impune lacessit," a motto as applicable to a gun as to the order of the Thistle of Scotland.

The English 9-pounder gun fires at pleasure three different projectiles—ball, canister and a shell filled with bullets called "shrapnel."

The ball, which weighs 9 lbs., is not, as in France, attached to the charge, so as to form a cartridge, it is merely affixed to a wooden bottom by a very ingenious process.

The shell of the kind termed "Boxer's" is divided by a diaphragm into two compartments, of unequal sizes. The larger contains 41 balls, of a mixture of lead and antimony, and coal dust to fill up the interstices. The smaller is reserved for the explosive charge, which is 1·50 oz. and which is introduced through a charge hole, drilled in the wall of the shell. A copper box, screwed into the eye of the projectile, receives at the moment of loading a graduated fuze. The shell charged weighs 7 lbs. 9 ozs. The canister is of tin, with an iron bottom and a wooden base. It contains 41 iron balls of 5 oz. each—its total weight is 13 lb. 1 oz.

The charge of powder is the same for all the projectiles. It is 2 lb. 8 oz., that is to say, a little more than a quarter of the weight of the shot. The munitions are contained in the boxes, carried as in France, on the limbers and the waggon.

The limber, which is common to the gun carriage, and the waggon, carries two boxes of equal size, divided each into three divisions, at the bottom of which are ranged 16 projectiles, retained in their place by shelves forming lids. The divisions for the shells and shot are filled up by two fuze bags of waterproof cloth, containing each eight charges. In the left hand box of the gun limber, the division for the canister shot contains the fuzes, the necessary tools for charging the shells, and boring and fitting fuzes, quick match,

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pincers &c. Finally, under the lid are fixed, in leather cases, a hand-saw and some portfires. The waggon carries two boxes, of a capacity double that of those on the limber. The boxes, likewise divided into three divisions, contain each 32 projectiles and their charges.

The gun carriage and the waggon carry altogether 92 balls, 20 shrapnels, and 16 canisters—in all, 128 rounds, the same as for the French 8-pounder gun, discontinued in 1853.

In general appearance, the English gun carriage and waggon nearly resemble the French carriage and waggon, and their construction is founded on the same principles. It is evident that each of the two nations have wished to profit by the improvements adopted by the other. However, there exist between the two systems differences of detail which it is well to point out.

The English gun carriage carries between the brackets and the wheels, two small boxes, intended to contain some stores of a small size, such as thumbstalls, nails for spiking, spare spunge head, slow matches &c. In the right hand box, two canisters can, previously to action be placed in reserve, to fire as last round against a charge of cavalry.

The elevating screw is attached to the button of the breech; it ascends or descends by means of a moveable nut. This system appears to have for its object, by fastening the piece to its carriage to diminish the recoil of the breech on the trail, in firing and manœuvring.

The English limber has shafts; this arrangement which answers very well in England, has been many times tried without success, in France, the pole has always had the preference. These shafts are very solid; the power that exists of fitting them in the centre, or on the right side of the splinter bar, affords the means of harnessing, according to circumstances with one, two or three horses, abreast.

Between the two ammunition boxes, the limber carries a small box, in which are some spare iron work and open links,

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intended to reunite the two portions of a broken chain. The drag washer is fitted with an eyebolt to which is hooked a drag rope, on which the men pull when passing over difficult ground.

Under the two ammunition boxes of the waggon are carried four shelves supported by straps, one of these contains grease for the wheels, the others hold 30 sets of horse shoes with their nails. The spare wheel is carried in front of the boxes on a false axletree placed above the perch.

Besides the ammunition and implements of the piece, and the intrenching tools, the carriages carry a grease magazine for the wheels, the appliances requisite for the more urgent repairs, pegs and cords to picket the horses in camp, leather buckets to water them &c. This large number of articles, arranged with so much regularity and care on the carriages, evidences how much attention is paid in England to the welfare of the soldiers. In brief, nothing is neglected to spare them all that could increase the hardships of marching. Their knapsacks are fastened on the boxes. Their carbines are attached to the boxes by straps, their cooking utensils most ingeniously stowed into camp kettles are suspended under the waggons. In a word, the carriages are loaded with all that constitutes the necessary comfort of the English soldier, probably in anticipation of expeditions into countries devoid of all resources. In France, however, they aim at reducing as much as possible the number of accessories borne on the gun carriage and waggon, the camp equipage, the cooking utensils, the knapsacks, the small arms are carried by the men, the implements and the greater portion of the stores and of spare articles are retained in the rear, on special vehicles. Every thing is done to lighten the combatant part of the battery in order to allow it to manœuvre with rapidity.

The carriages of an English battery are drawn according to requirement by 6 or 8 horses, harnessed like ours, trace to

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trace. The near horses have all the same appointments; the off wheeler which is harnessed in the shafts has breeching and a small baggage saddle more than the centre and leading horses. The drivers' saddle is plain without holsters or valise, the latter is attached to the pad of the off horse.

The traces are rope and covered with leather where they come in contact with the horses sides.

All the rest of the harness is of a fawn colour; its appearance is elegant, simple, and admirably adapted to its purpose.

In the English artillery, the woodwork of the carriages is painted grey and the ironwork black. But in the equipment presented to His Majesty the Emperor, the woodwork is varnished and the ironwork polished with care. This arrangement allows all the perfection of this remarkable piece of workmanship to be appreciated.

The wood is of great beauty, of a superior quality, and faultlessly worked up: the appurtenances leave nothing to desire. The ironwork is of irreproachable workmanship, and is polished with most particular care. The intrenching tools are very remarkable, and rival all that the universal exhibition of 1855 has made us acquainted with of the best of this description. In short nothing could be more ingenious or better constructed than the small set of tools for spiking ordnance, and filling shrapnels.

All that composes this magnificent specimen of English artillery, gun, carriages, stores, &c. proceed from the workshops of the Royal Arsenal at Woolwich, a splendid establishment, which, by means of its powerful and ingenious machinery, and of its advantageous position supplies by itself all the necessary materials for the artillery.

In conclusion, the present of Queen Victoria is a true masterpiece, which would suffice to give us a high and just idea of English material, if the experience of the war in the

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East had not shown us, more evidently still, its indisputable advantages.

(Signed) P. De Courtin.

The Boat Armament of the American Navy.

In an article on the new American steam ships of war, in our number for October 11, brief reference was made to the use of light wrought-iron gun carriages for boat service. We find that opinions are divided with respect to the merit of these carriages, and much discussion has taken place upon the subject. For this and other reasons we think that further information respecting the armaments of the boats in the United States' Navy will be received with interest by our readers. In supplying this we shall ensure accuracy by deriving our information from the published papers of Commander Dahlgren,* who has charge of the Ordnance Department of the Navy-yard at Washington. This department has grown into importance since 1848 under his superintendence, and now includes a fine building, containing a considerable quantity of steam and other machinery, separate rooms for fitting shells, a foundry for casting bronze howitzers, &c.

The following are among the regulations prescribed by the Navy Department (December, 1850) for the furnishing of boat-guns and field-pieces for vessels of the Navy:—All boat-guns and field-pieces are to be of bronze, of howitzer form, and are to be chambered; they are to be of 12-pounder and 24-pounder calibre, and their greatest weights are to be 750 lbs. (and 450 lbs. for a lighter class) and 1200 lbs. respectively; ships of the line and frigates are to have one 24-pounder boat-gun, and one 12-pounder field-piece, with a suitable carriage for each; for each 12-pounder there shall

* Particularly "Boat Armament of the U. S. Navy." Philadelphia: King and Baird, 1856.

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also be a boat-carriage prepared, by which a field-piece and a boat-gun, or two boat-guns, as may be necessary, may be used.

The principal object of boats'-guns being to destroy life rather than material, howitzers are used (figs. 1 and 2,*) and with them shell or shrapnel. The howitzers used in the various boats of the United States' Navy differ only in weight and dimensions. "In their design I have followed," says Commander Dahlgren, "the utmost simplicity of figure and dispensed with all ornament." The piece is cylindrical around the charge, and tapers thence towards the muzzle. The breech end is of the form of a portion of a sphere. The bore is terminated by a conical chamber (Fig. 3*); the chief inducement for preferring this to the cylindrical form, in the case of these howitzers, being the greater facility it affords for rapid loading, without danger of failure in the ramming home of the charge. A screw is used for elevating them, and, for convenience in working rapidly, a light disc, coarsely milled around its edge, is used instead of a lever for turning the screw. The lock is a plain hammer perforated at the head, so as to permit free egress to the blast from the vent. It plays in a lug cast on the piece in the rear of the vent, and is so arranged as not to interfere with the pointing of the piece. A round tangent sight is made to move in a perforation drilled for the purpose in the rear of the base ring. No breechings for checking the recoil are used, being found superfluous; if the means used for the purpose (described hereafter) should ever be found inadequate, a thimble to receive a breeching can readily be fitted to the neck of the knob. The principal dimensions of the boat howitzers are as follows:—

* Plate 37.

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	24 Pounder.	Medium. 12 Pounder	Light. 12 Pounder.
	Inches.	Inches.	Inches.
Diameter of bore	5·82	4·62	4·62
True windage	·10	·10	·10
Bore. length including chamber	58·20	55·23	44·00
Bore. in diameters	10	12	9½
Chamber, length	6·00	5·23	5·23
Length from B, R to muzzle-face	58·20	56·23	45·24
Diameter of cylinder	11·42	9·00	8·00
Ditto chase	8·82	7·24	6·42
Length of cylinder	15·00	12·00	10·00
Ditto chase	43·20	44·23	35·24
From base ring to axis of loop	23·75	24·60	18·78
Hole in loop, length	7·00	5·00	3·60
Ditto diameter	2·50	2·03	1·50
Weight	1310 lbs.	760 lbs.	430 lbs.

Each of the boat carriages (fig. 2) is composed of three principal pieces—the bed which carries the howitzer, the slide on which the bed moves, and, beneath the slide, a wooden plate connected with the bed by two stout bolts.

The recoil is controlled by compressing the slide between the bed and the lower plate; for which purpose the bolts connecting the upper and lower pieces have a thread above, and a corresponding nut with handles. These are set as firmly as the strength of an ordinary man can set them, and suffice to keep the recoil within the limits of a slot in the slide. After the discharge of the piece, the compression is relieved, and the piece is run out. When the carriage is new, the sliding surfaces occasionally require adjusting, owing to the warping and twisting of the material of which they are formed. The efficacy of this method of receiving the recoil may be judged of from the fact that although, in a certain instance, when a 12-pounder was mounted rigidly in a frigate's cutter 27½ feet long, with twelve persons in it, besides gun, ammunition, oars, &c., the cutter was driven back by the recoil many yards astern; yet no injurious effect whatever was produced upon the boat—even the paint upon the plank-ends being undisturbed—when the same piece was mounted upon its own carriage, and discharged a hundred times

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Miscellaneous

Fig. 4.

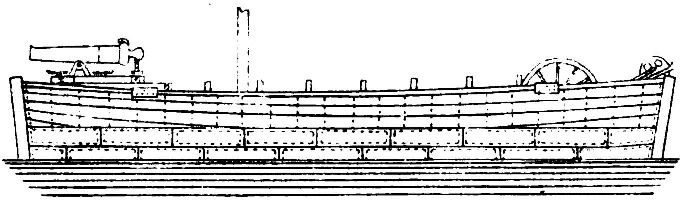


Fig. 5.

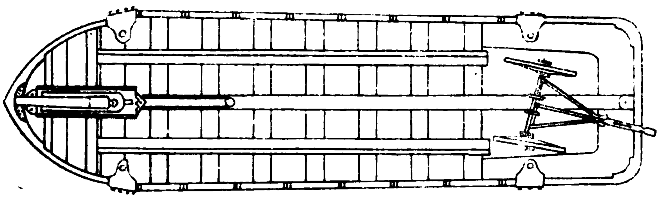


Fig. 6.

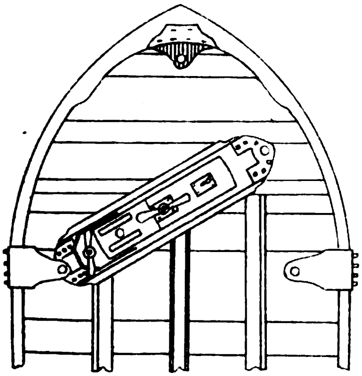
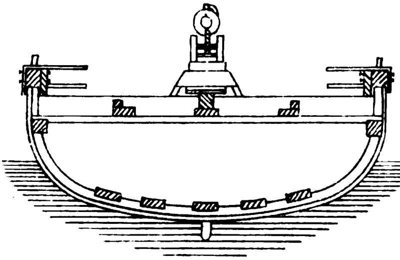


Fig. 7



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while the boat was under full way. Commander Dahlgren says, "The greatest rapidity with which it is desirable to deliver the fire of light pieces is attainable with this mode of mounting," and Lieutenant Decamp states that, "in shelling an African village, the howitzer was fired from the launch at the rate of 5 times in the minute."

We now come to the wrought iron field carriages (fig. 1,) upon which the 12 pounder of 750 lbs. is mounted when disembarked with parties of seamen for land service. These carriages are the result of great care and trouble, much difficulty having been experienced by the designer in retaining the necessary strength while reducing the weight to the least limit. The trail has a small wheel or runner to ease it over any obstacle, and it is found preferable in draught to attach the drag rope to the trail. The carriage weighs rather less than 500 lbs., and with its piece is drawn readily by the force always disposable from any boat that could carry a gun of this class. The parts of the carriage are held together by screw nuts, so that no difficulty ought to arise in taking it apart, if desirable to do so. The axle or pin of the trail wheel is to be drawn out, and the wheel itself turned up on the trail, in order to moderate the recoil on smooth ground. No limbers are used with these carriages, it being assumed that, for every safe and judicious movement of seamen on shore, the ammunition slung under the axles, and carried in the pouches of the men (about seventy rounds each gun) would fully suffice. When more than a single piece is landed, and a march anticipated, the trail of one field carriage is secured to the axle of another.

The projectiles used in howitzers are shells and canister, to which it is now usual to add shrapnel of an improved kind. In the new plan the balls are more closely packed than formerly, and the interstices filled with sulphur, which solidifies and imbeds the balls, so that they cannot move, and the interior of the shrapnel is thus filled solidly. A cylindrical

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cavity is also left, the axis of which coincides with that of the shrapnel axis, and which passes through the fuze-hole, extending across the interior. In this cavity is deposited the charge of powder, where it is protected against all injury and liability to premature explosion, from the movement of the balls. By this arrangement the quantity of powder required to open the shrapnel is much lessened, the new plan requiring only ¾ ths. of an ounce, or an ounce, while with the loose balls 4 oz. are required. The fuze employed is Colonel Bormann's, of the Belgian Artillery. It is composed of a metallic disc, about 1·6 inches in diameter, and ½ inch thick, made of lead hardened somewhat by the infusion of some tin. On its exterior are screw threads, by which it is screwed into the shrapnel case. The fuze composition is firmly condensed in an interior canal of this disc opening below, and closed, after the composition is driven in, by a small slip of soft metal driven in upon it. The upper surface of the disc is thin enough to yield readily to a cutting tool, by which it is opened. Outside the disc is graduated to seconds and fourths of seconds. The end of the composition where the graduation begins opens into a small magazine at the centre of the disc, and this magazine is charged with grained powder, and slightly closed on the inner side so as to yield in that direction to the explosions. The charges of the boat-howitzers are :—24-pounders, 2 lbs.: 12-pounders, medium, 1 lb.; 12-pounders, light, 0·625 lbs. In terms of their heaviest projectiles, the weights of these pieces are, 24-pounders, 55; 12-pounders, medium, 63; 12-pounders, light, 36.

The appliances for mounting the howitzers in boats will be best understood from a description of a frigate's launch, fitted for actual service (Figs. 4, 5, 6, and 7, Plate 38.) This boat is 34½ feet in length, and has an extreme breadth of 11¼ feet. The boat carriage is so placed in the bow as to carry the muzzle of the howitzer just above and clear of the gunwale and stem. Two pieces of yellow pine are laid athwartships, so as to bear the carriage at this height, and on them it

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traverses when pivoted at the stem. The warping chocks at the stem and stern-post would be arranged so as to be moveable when the gun is used. The two iron plates for receiving the slide are welded into one piece, which is firmly bolted beneath the breast hook of the bow. When pivoting on the stem or stern plates, the howitzer has the sweep permitted by the form of the boat. Two pivot plates are bolted on each bow, so that the howitzer may be trained more or less on the beam, the stem plates being adjusted first, and the carriage fitted in. The distances between the bolt of the stem plate and that of either bow pivot must be equal to the distance between the holes in each end of the slide, and the pivot bolts of the two bow plates also correspond to the same distance. The pivots are thus at the points of an equilateral triangle, which provides for a rapid and certain management of the gun in changing its position. To sustain the carriage in sweeping, when pivoted to the bow, a piece of yellow pine scantling is placed lengthwise and amidship, mortised into the after cross piece. The arrangements for the stern are adapted to the same principle.*

Remarks on Colonel P. Anstruther's Pamphlet on the "Flight of Projectiles" by the Reverend J. Richards M. A.

My dear Major Briggs,

I have looked with some attention through Colonel Anstruther's pamphlet on the "Flight of Projectiles",† and according to your request I proceed to lay before you a few observations thereon. Had it involved questions of practical Gunnery, I should certainly have hesitated,—but as it seems merely to deal with well known dynamical principles, I may perhaps venture to communicate to you such conclusions as I have been enabled to arrive at.

2. The author's object seems to be, to simplify the great problem of Gunnery; and certainly, if his theory be sound,

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* Mechanics Magazine, November 15, 1856.

† From page 534 to page 549 and page 597 Artillery Records.

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he has succeeded in reducing it to the simplest conceivable form, making its practical solution to involve nothing more than the solution of a right angled triangle.

3. It is often very difficult to ascertain exactly the author's meaning, as he does not reason mathematically, although he uses mathematical language.—Moreover it is to be regretted that more care was not taken in elaborating the argument; for, not only is very much left to the reader to supply in order to maintain its continuity, but there is so much looseness in the definitions of terms, and in the statements of the propositions, that the latter seem often flatly to contradict each other—To take a single example:—in the "Argument" introductory to the pamphlet, it is said (para 4) "Fire another ball vertically upwards with velocity equal "to V, which would take it to Y," whereas, in para 2, he states that a ball fired upwards with velocity V will go only "*half as far as* Y". It must be assumed however, probably, that different conditions are supposed in the two cases.

4. It is a well known result of the laws of rectilinear motion, that a body projected vertically upwards *in vacuo* with a given velocity will rise to the height due to that velocity, and in its descent acquire a terminal velocity equal to the velocity of projection, the time of descent being exactly equal to that of ascent: for example, adopting the notation of the author, suppose the velocity of projection to be $12S$ ($S=16{\cdot}1$ ft$=\frac{1}{2}g$), to find the time of ascent,

$$v=V-gt=0 \text{ at the highest elevation}$$

$$t=\frac{V}{g}=\frac{12S}{2S}=6'' \quad (g=2S)$$

$$\text{The height}=Vt-\tfrac{1}{2}gt^2$$
$$=12S\times 6-S\times 36$$
$$=36S$$

Now a body falling from this height will reach the spot from whence it rose in time $t'=\sqrt{\frac{36S}{\frac{1}{2}g}}=\sqrt{\frac{36S}{S}}$

$$=\sqrt{36}=6''$$

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hence the whole time of ascent and descent $=t+t'=12''$

This is *in vacuo*; but in practice another important element comes into the calculation; viz, atmospheric resistance.—Now, says the author, taking this element into the account, (para 2 of the pamphlet), "By experiment we know that a "ball fired with this velocity, 12 S, will in 6 *seconds of time* "return to the spot from whence it rose," *i. e.* in *half the time* which it would take *in vacuo;* moreover, as it would appear from para 2 of the "Argument," rising to only *half the height* to which it would rise *in vacuo*—The author says not a word more about this important experiment on which his theory appears to rest, leaving us to draw the inference, which I presume is to be drawn, that it is only with that particular velocity of projection, 12S, that the above result was obtained.

5. Assuming however for the present, with the author, the certainty of this experimental result, viz, that a ball projected upwards with a velocity, 12 S, will come back to the point of departure in (6″) half the time, which it would take *in vacuo*, rising to only half the height.—I will endeavour to follow him some way in the development of his theory.

6. Now, following the second law of motion which, in the case of a body acted upon by different forces, enables us to estimate the *separate* effect of each force, we may suppose the ball in question to be thus acted upon,

1st. By the velocity of projection, which would make it move uniformly in the same direction, *i. e.* would cause it to rise $6\times 12\ S=72\ S$ in 6″.

2d. By the force of gravity, which would cause it to move with uniformly accelerated velocity in the direction opposite to that of projection, *i. e.* would cause it to descend $\frac{1}{2}g^2t= S\ \times 6^2=36\ S$ in 6″.

3rd. By the force of atmospheric resistance, which is a variable force, always acting in a direction contrary to that of the *actual motion* of the ball, and producing a varying velocity.

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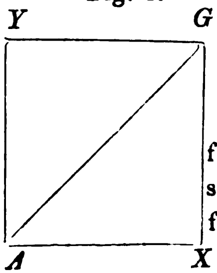
Now, since with the velocity of projection *alone*, the ball would rise 72 S in 6″, and under the action of gravity *alone* it would fall 36 S in that period; and since in the same period it actually returns to the point of departure, the residual motion of 36 S in 6″ must be due to the force of resistance, and is therefore taken by the author as the measure of that force.—Again, since gravity is an uniform force always acting *downwards* and producing a motion of 36 S in 6″, we might seem to be able to assume, from the above reasoning, that the combined effect of the velocity of projection and atmospheric resistance is equivalent to an uniform force always acting *upwards* and producing a motion of 36 S in 6″.

7. The author then appears to assume two uniform forces acting in opposite directions and in the period of 6″ neutralizing each other's effects;—viz, the *actual* force of gravity acting downwards, and generating equal increments (2 S) of velocity per second, the velocities at each successive second being in an arithmetical series, with a terminal velocity of 12 S; and a *hypothetical* force acting upwards, with an initial velocity of 12 S, and producing equal *decrements* (2 S) of velocity per second, the velocities at each successive second being in an *inverse* arithmetical series, and the terminal velocity being zero.—Now for a moment setting aside the force of gravity, and considering only this hypothetical force acting vertically upwards;—suppose a *horizontal* force exactly equal to the above applied at the same moment to the ball.

Fig. 1.

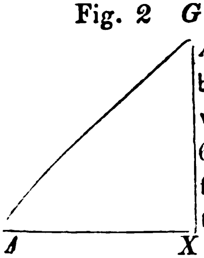


Let AY represent the vertical force $AX = AY$ the horizontal

Then AG, the diagonal of the square formed by these lines, will represent the resultant of these forces; and that resultant force will bear to each of the other forces (to the vertical force, say) the ratio of $\sqrt{2} : 1$; in other words, if

AY represent an uniform force, with an initial velocity of 12 *S*, and producing equal decrements (2 *S*) of velocity per second, *AG*. will represent an uniform force, with an initial velocity of $12\sqrt{2}\,S$, and producing equal decrements ($2\sqrt{2}\,S$) of velocity per second.—This resultant or " diagonal" force now becomes the author's hypothetical force, and is assumed to be equivalent to the combined effect of a velocity of projection of $12\sqrt{2}\ S$ (instead of 12 *S* as before) and the atmospheric resistance.—Now considering only the right angled triangle

Fig. 2



AGX, the above force being represented by *AG*, the force of gravity acting downwards and producing a motion of 36 *S* in 6″ will be represented by *GX* (=*AY* in fig. 1) and *AX* will represent the range of the ball.—Thus the solution of the problem of Gunnery is made to resolve itself into the solution of a right angled triangle.

8. I hope I have not misrepresented the author: I can only say I have not done so willingly.—I may have misunderstood him, but it is not from want of a real desire and an earnest endeavour to eliminate his meaning.

9. I do not think it necessary to follow the author into the applications of his theory; nor do I think it necessary to verify each successive step of the above reasoning so as to ascertain whether it is perfectly sound in principle.—The question at present, as it seems to me is;—is the fundamental *experiment* on which this reasoning is based, indisputable and beyond a doubt? The author has given us no information respecting the experiment; he has simply stated the fact.—I have examined all the works on Gunnery within my reach, and inquired of some of the leading Officers of your Regiment, and can find no record of such experiment; in the absence therefore of all information, I am constrained to ac-

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knowledge, with all possible deference to the accomplished author, that I do feel doubts about it.

10. For there can be no doubt whatever, that a ball projected vertically upwards with a velocity of 12 S* (193·2 feet) *in vacuo*, will return to the place from whenc it rose in 12 *seconds of time.*—Now this is a decidedly *low* velocity (193·2 ft), and it is laid down, I apprehend, by all authorities on Gunnery, that with an initial velocity of less than 200 or 300 feet, the resistance of the atmosphere is small, and the results obtained from the theory of motion *in vacuo* are *approximately true.*—But surely there is no approximation whatever between 6″ and 12″.

* $S=16{\cdot}1$ ft.

11. Again, supposing the result said to be obtained with a given velocity of projection to be depended npon,—this would, I apprehend, afford very insufficient data for a generalization such as that of the author.—With higher velocities of projection, the results would vary considerably; the atmospheric resistance being a *variable force*, it would be clearly impossible *generally* to represent the combined effect of it and the velocity of projection by an *uniform* force, as we have conceived it possible to do in the hypothetical case above considered.—This seems to me (I speak however with the utmost diffidence) to be fatal to the theory.

12. The only recorded results of an experiment on vertical projection which I can find, are those mentioned by Major Simpson in Part II of the "Young Artillery Officer's Assistant".—I presume that these are to be understood as the results of actual experiment. It appears then, that a 24 pdr. shot projected upwards with a velocity of 2000 feet rose to the height of 6,424 feet in nearly 9½ seconds, and then accomplished its descent in 16 seconds; *i. e.* it returned to the spot from whence it rose in 25½ seconds. Let us now calculate its flight *in vacuo*.

$$t=\frac{V}{g}=\frac{2000}{32{\cdot}2}=62{\cdot}1'' \text{ nearly}\left(\text{time of ascent.}\right)$$

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$$h=\frac{V^2}{2g}=\frac{(2000)^2}{64\cdot4}=62,111 \text{ feet nearly (height of ascent.)}$$

$$t'=\sqrt{\frac{2h}{g}}=\sqrt{\frac{124223}{32\cdot2}}=62\cdot1'' \text{ nearly (time of descent.)}$$

$$\therefore\ t+t'=2\times62\cdot1''=124\cdot2 \text{ seconds.}$$

Hence time in experiment : time *in vacuo* :: $25\frac{1}{2}$: 124·2 *i. e.* :: 1 : 5 nearly; in other words, the ball returned to the place from whence it rose in *one-fifth* of the time which it would have taken *in vacuo*. This experiment then presents totally different results to that of Colonel Anstruther, even taking into account the difference of initial velocities.—I should be glad if Major Simpson would favor me with further particulars of this experiment.

13. In conclusion I venture to express my opinion, that if the verification of the author's tables is considered to be a task of much labour and expense, it would be highly desirable that further light should be first thrown both upon the theory itself, and especially on the experiment, on which it appears to rest.

Believe me,

St. Thomas' Mount, 17*th June* 1858.

Yours very sincerely,
(Signed) John Richards.

Letter from Colonel P. Anstruther C. B. Madras Artillery to the Brigadier Commandant of Artillery on the flight of Projectiles.*

Sir,—1. On this day of last year, the Sub-Committee of the Ordnance Select Committee pronounced their opinion on my proposition; terming it a "hypothesis, unsupported by "any shadow of reasoning and contradicted alike by theory "and fact."

2. Before two months had elapsed, I obtained a copy of their decision, and have, since that time, been busily trying to prove by words, what half an hour's practice with a 68 pounder would prove beyond doubt.

* Vide pages 534 to 549 and page 597 Artillery Records.

3. I propose now to contest the theory, which, I admit, does contradict mine; as far as I can guess where it is to be found, no indication whatever being afforded me for guidance, but I think I am safe in quoting the Treatise on Mechanics by Olinthus Gregory, vol. 1. p. 198, 3d edition, as embodying the theory held by the Ordnance Select Committee of Woolwich to be correct.

4. Gregory says that a ball thrown vertically upwards, returning at the end of 18 seconds, ascends during 9 seconds, 81 times 16 feet, with velocity $32 \times 9 = 288$. He is wrong demonstrably, for,

5. A shell fired at 45° with such charge as will give it 18 seconds time of flight, has exactly the vertical velocity which the ball in Gregory's example had, it ascends and descends, returning in 18 seconds to the ground; and being fired at 45°, it has horizontal velocity exactly equal to its vertical velocity; hence we read, in its actual horizontal range, the exact measure of what would be its vertical ascent, if the vertical were, as the horizontal is, free from the counteraction of gravity. It does range $18^2 \times 16\frac{1}{12}$, or $18^2 S$, or $324 S$, employing the letter S to denote the space $16\frac{1}{12}$ feet. It therefore would ascend $18^2 S$, or $324 S$ if it were not counteracted by gravity.

6. Gregory seems to think that gravity does not oppose the ascent, but commences when the ball culminates, and does fetch it back again, but most certainly the action of gravity commences with the first instant of ascent exactly as in the case of a ball at rest, 1, 3, 5, 7, 9, &c. Spaces in successive seconds.

7. We had formerly in use a phrase, now forgotten, "Feet per second mean velocity," which we got by dividing range by time. Using this rule we should find that Gregory's initial velocity is the same as the mean velocity. If it were so, a ball retains its initial velocity throughout its flight. This is surely quite sufficient to prove Gregory to be wrong, it is mere repetition to say what I think is right.

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8. The ball being fired upwards, commenced its fall by gravity exactly at the same moment as it commenced its ascent, the ascent constantly diminishing in velocity, the descent constantly increasing, till in nine seconds the half ascent and half descent equalled each other, and a descent was seen to commence. In 18 seconds the ball descends 18^2 S, it therefore would have ascended 18^2 S, if not counteracted by gravity. Falling during 18 seconds it would have acquired downward velocity $36S$, it must therefore have had initial velocity $36S$. Gregory gives half this.

9. In so doing he is supported by Mr. Cape, the Mathematical Professor at Addiscombe, vide, his 2nd. volume, p. 216. He says an arrow returning in 10 seconds had velocity 161 feet, and rose to 402·5 feet. I say that such arrow, or ball, would rise as follows:—

$321{\cdot}666 \times 10 = 3216{\cdot}666$ feet, not resisted by the atmosphere, not resisted by gravity.

1608·333 feet, resisted by atmosphere, not resisted by gravity.

804·166 feet, resisted by atmosphere, and resisted by gravity.

402·5 feet, by Gregory's, Mr. Cape's, and the Woolwich Select Committee's theory as I suppose theirs to be. The exact measure of the resistance of the atmosphere is here shewn, simply enough; this is for some reason or other always treated as a great mystery. The ascent aad descent in 10 seconds is as follows:—

1	3	5	7	9	11	13	15	17	19	S descending,
19	17	15	13	11	9	7	5	3	1	S ascending,
18	14	10	6	2	2	6	10	14	18	difference,
18	32	42	48	50	48	42	32	18	0	apparent, and

real result. It really went up $50S = 804\frac{1}{6}$ feet with initial velocity $321\frac{2}{3}$ feet per second.

10. I quote this to show that it is not an accidental misprint nor the hasty admission of an immaterial point but the

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deliberate opinion of two learned civilians, which moreover I believe to be the theory backed by the authority of the Ordnance Select Committee of Woolwich.

11. I will now conclude by requesting you will furnish me with the ranges of the longest gun conveniently procurable, fired at all elevations from 5° to 85° with the largest shells procurable, made as heavy as possible by running melted lead in, with any one such charge as you may think safe for the gun.

12. I need not say that mere opinions, mere judgment of probable results, I do not ask for, as no man's opinion can carry greater authority than that against which I appeal; on the contrary, I should suggest that any expression of opinion would very materially affect the reliance to be placed on the results of the subsequent experiments.

P. Anstruther, *Colonel,*
Madras Artillery.

1, Chapel Street,
Grosvenor Place,
30th April, 1858.

Remarks on the foregoing letter from Colonel Anstruther C. B. to the Brigadier Commandant of Artillery on the Flight of Projectiles; by the Reverend J. Richards M. A.

My dear Major Briggs,

The letter of Colonel Anstruther to the Brigadier Commandant of Artillery, with a perusal of which you have favored me, has astonished me not a little.—It leads me to suspect that the author totally misapprehends the elementary principles of Dynamics as applied to Projectiles.—The theory which he " proposes to contest" is as well established as Euclid's Elements of Geometry.—The whole fabric of modern science is based upon it.—It is *puerile* to talk of contesting it.—One might as well talk of contesting the *theory,* that " the three angles of a triangle are equal to two right " angles."

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2. I am unable to consult Gregory's and Cape's Treatises for the problems referred to by Colonel Anstruther; but I presume they are such as I have stated them in the Notes which I have hereto appended; and, if so, the results are *demonstrably right,* unless the Colonel is prepared to overthrow the whole science of Dynamics.—But then, it should be carefully borne in mind, the motion is *in vacuo.*

3. The real source of Colonel Anstruther's error, *I suspect,* is his introduction of the force of *resistance,* under the mistaken notion that it is an uniform force, or, that it may be *treated* as an uniform force, like that of *gravity*; and into this mistake he appears to have been led by some experiment, real or imaginary, which was supposed to give the *time of flight* and the *height of ascent,* of a body projected vertically, *each, exactly half* of what it would be *in vacuo* according to the established theory of rectilinear motion.

4 The Ordnance Select Committee at Woolwich, it appears, have designated Colonel Anstruther's proposition, a "hypothesis, unsupported by any shadow of reasoning and "contradicted alike by theory and fact."—In my former communication I attempted to *supply* the reasoning, by which I conjectured *he might possibly have arrived* at his theory, without pronouncing an opinion whether that reasoning was sound or not.—Now however I am led to doubt whether his hypothesis was arrived at by *any reasoning* on dynamical principles.

5. I can only say further that I entirely concur in the opinion pronounced by the Woolwich Select Committee.

I remain

Mount, 21*st June* 1858. Yours very sincerely,
(Signed) John Richards.

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Notes on Colonel Anstruther's letter to the Brigadier Commandant of Artillery.

para 4 The problem here referred to, *I presume*, is as follows,—

A ball projected vertically upwards returns at the end of 18 seconds with a terminal velocity of 288 feet.—Required the height of ascent.

The motion is *of course* understood to be *in vacuo.*

Now initial velocity = terminal velocity

$$= 288 \text{ ft} = 18S(S = 16 \text{ ft.})$$

Time of ascent = time of descent

$$= 9 \text{ Seconds}$$

To find the height h

If V be velocity of projection $= 18S$

v velocity at any instant

g the measure of gravity $= 32$ ft $= 2S$

Then from the equation

$$v^2 = V^2 - 2gh$$

since $v = 0$ at the greatest elevation

$$V^2 - 2gh = 0$$

$$h = \frac{V^2}{2g} = \frac{(18S)^2}{4S} = \frac{324S^2}{4S} = 81S$$

$$= 9^2 S$$

Colonel Anstruther says (para 5), the ball "would ascend $(18)^2 S$, if it were not counteracted by gravity;" he means it would ascend $(18)^2 S$ in 18 *seconds.*—Just so:—with the velocity of projection *alone*, it would, in 18 seconds, ascend $18 \times 18\ S = (18)^2 S$,—and gravity acting *alone* during 18 seconds would cause it to *descend* $\frac{1}{2}g\,(18)^2 = (18)^2 S$.—

$g = 2S$ Hence, with their *joint simultaneous action*, at the end of 18 seconds, the motion in one direction is exactly counteracted by the motion in the other, and the ball is just where it was at the commencement of the period. But the question is, where would the ball be at the end of 9 seconds.—Now with the velocity of projection *alone*, it

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would, in 9 seconds, *ascend* $9\times 18S$.—Gravity acting *alone* during 9 seconds would cause it to *descend* $\frac{1}{2}g\,9^2=9^2S$.—Hence with their joint simultaneous action, the total ascent will be

$$9\times 18S-9^2S=9^2S$$
$$i.\ e.\ 162S-81S=81S$$

the maximum height of ascent.

Colonel Anstruther's error, which is *palpably shewn* in para 8, consists in this,—in supposing that gravity, acting during 18 seconds, is during the whole of that period *actually generating velocity downwards.*—Not so; during 9 seconds its action is to destroy the upwards velocity caused by projection:—at the end of 9 seconds that velocity is destroyed:—*then,* and then only, it *actually* begins to generate velocity downwards, and the terminal velocity is the velocity genera-

$g=2S$. ted during that latter period of 9 seconds viz. $g\times 9=2S\times 9=18S=$ initial velocity.

Para 9. The problem here referred to *I presume,* is as follows:—

An arrow shot upwards with a velocity of 161 feet, returns at the end of 10 seconds.—Required the height of ascent.

$$v^2=V^2-2gh=\ \ 0$$
$$\therefore\ h=\frac{V^2}{2g}=\frac{(161)^2}{64\cdot 4}$$
$$=402\cdot 5$$

to find time of ascent

$$v=V-gt=\ \ 0$$
$$t=\frac{V}{g}\ \ =\frac{161}{32\cdot 2}$$
$$=5\text{ seconds}$$

but this *we know,*—for it is one half of the whole time of flight *(in vacuo).*—There need be no hesitation in saying that Colonel Anstruther's results are altogether *erroneous* and *groundless.*

(Intd.) J. R.

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Patent Maresfield Gunpowder.

This gunpowder, which is of perfectly novel introduction, is the result of a course of successful experiments made by a gentleman formerly connected with the Royal Gunpowder Works at Waltham Abbey. Why the discovery was not confined to those works; why the government did not secure the services, and with them the patent right of the inventor, and why the process is now in the hands of a public company, is no present business of ours, and the particulars would, if given, but tend to lead us into one of those controversies which have been unhappily too frequent of late, and which would only multiply charges against that truly English and singularly anomalous power—a British government. Suffice it, that it was at the Royal Mills the secret of the new powder was discovered, and that the results and advantages are now a "commercial fact." Hitherto the manufacture of gunpowder has been almost exclusively confined to two firms, unless we consider the government as another. It is equally strange that the three components—charcoal, sulphur, and saltpetre, are the same to-day as they were about the period that Roger Bacon existed. Nor does any change appear to have waited upon the present patent, the whole secret consisting apparently in the more intimate amalgamation of the ingredients. In the ordinary gunpowder, when let off, these three substances did not start fairly, one or other of the three being slower than the others, and consequently left behind. This want of rapidity in the one retarded likewise to a certain extent the other two; but in the present mode of admixture a fair and simultaneous start is made, and the three disappear with a greater detonation, little or no residue remaining upon the spot from which they take their departure. This gunpowder, in consequence of this attribute, is called "Electric," and truly deserves the title. One of the manufactories already at work is at Maresfield, Sussex, but the name it has already acquired, although this mill is kept in

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constant action, has caused a demand for it for sporting purposes, which cannot at present be fully supplied. This will, however, be soon rectified, as most extensive arrangements have been entered into to extend the plant, not only at Maresfield, but at the Plymouth and Dartmoor Gunpowder Companies' Works, to fully meet the want. The latter Company will devote their energies to the production of gunpowder for blasting purposes, as the extra strength of this patent gunpowder, and the absence of smoke, has already induced the proprietors of important works in Wales, and in the west and north of England to enter into large contracts for its regular supply.*

Whitworth's Patent Ordnance and Rifles.

The following is a description of the improvements in cannons, guns, and fire-arms for which Mr. J. Whitworth, of Manchester, has recently obtained letters patent, dated December 1, 1854.

The invention consists, firstly, in constructing cannons, guns, and the barrels of fire-arms, in separate parts, and uniting together, by means of hoops or belts, two or more segments made of a particular shape (as hereinafter described), which when so united form a cannon or other piece of ordnance, or the barrel of a fire-arm, the interior of which may be rifled, not by boring and cutting grooves in it, as in the ordinary mode, but by making the interior in the form of a hollow polygonal spiral or screw of the requisite pitch and number of threads. The spiral figure adopted may have any number of sides, as may be found most suitable to the size of the piece; for an ordinary rifle it has been found advantageous to employ from six to eight sides, and for a twelve pounder cannon nine sides, as shewn in the engravings. Great accuracy is required in making the segments, as each should be the

* Mechanic's Magazine, November 29, 1856.

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exact counterpart of another; the surfaces of their edges intended to be brought in contact must be perfectly true, and be so shaped that the lines of junction in every case shall follow the course of the spiral, and bisect at every point one of the angles of the hollow spiral figure formed by all the segments when united. Their exterior surfaces may correspond in shape to the interior, or may be circular, so as to form when hooped together a conical surface tapering from the breech to the muzzle. The inner surfaces of the hoops or belts for uniting the segments will correspond with the outer surface of the segments on which they are fitted. The said hoops or belts may be made of any required breadth the most economical, and may be forced on the segments, so as to produce the requisite degree of tightness by a screw at the muzzle. The breech is formed by screwing a cap on the breech end of the segments which is pierced for the touch hole, and the trunnions are attached to one of the hoops or belts. The different parts of a cannon or gun barrel may be made of different materials; thus, the segments may be of cast or wrought iron, or of wrought iron and steel, or other suitable metal, and the hoops or belts may be of malleable iron or other metal, according as the quality of a particular metal in point of hardness or strength renders its employment desirable for a special purpose, as to withstand friction or resist a great strain. A second series of belts may be used outside the others for giving additional strength. These may be made of comparatively thin steel, and being put on hot would adjust themselves, and prevent the necessity of boring and turning.

" By this method of constructing cannon or barrels of fire-arms in segments, it is obvious," says Mr. Whitworth, " that the material will be comparatively easily dealt with, while the requisite accuracy may be attained in shaping the segments. It is necessary that the segments should contain a sufficient mass to give the piece solidity and steadiness in firing; at the

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same time it will be found, if the hoops or belts be made of a malleable metal, that it will yield to great pressure. The danger of a gun bursting from an overcharge of gunpowder will be obviated, because the strain will be distributed throughout the length of the segments, and by forcing the hoops or belts to give way cause the joints of the segments to open longitudinally, thus acting as safety valves, allowing the gases generated by the explosion to escape through the joints so opened. The piece may be spoiled by overstraining the parts, but its liability to burst will be prevented. In the case of heavy pieces of ordnance the facilities of transport are much increased, as by removing the hoops or belts the various parts may be disconnected and transported separately."

The patentee proposes to cast the barrel in one piece, and to cut a slit or slits along the angles, following the spiral course of the groove, the slit or slits to be filled by wedge pieces inserted from the outside, to which, if made thin, the spiral shape can be given them in a heated state. Up to a limited size of cannon this mode of construction might be desirable for the sake of economy, as it also allows of the adoption of wrought iron hoops in combination with the cast iron or other metal, as in the case of the segments before referred to. When it is important that the weight in a small cannon or fire-arm should be diminished, instead of constructing them in segments, as above described, the patentee finds it more convenient to make the tubular part in one piece, giving to its interior, however, the spiral figure, as before described, when segments were employed. He makes the exterior to taper from the breech to the muzzle either of the ordinary conical figure, or of a spiral angular figure, corresponding with the figure of the interior, so that in any transverse section there is uniformity of thickness and strength of metal. In the case of cannons so constructed, the trunnions are cast on, and the piece made open at both ends, to facili-

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tate the operation of the tool employed in shaping the interior; and when the cannon or fire-arms are made breech-loading, a cap is screwed on to form the breech, in the manner hereinafter described; when they are made to load at the muzzle, the breech is screwed in. It is to be observed that it has been found desirable to employ for the improved ordnance and fire-arms projectiles specially adapted to them (for which Mr. Whitworth obtained provisional protection on the 23rd April 1855, and which we shall hereafter describe), being partly conical in shape, but having in the part which is in contact with the barrel, spiral lines and surfaces cut upon them so that they exactly fit its interior. The description of the improvements will be fully understood by referring to the engravings.

Fig. 1 (Plate 39) is a longitudinal section, fig. 2 an end view, and fig. 3 across section, of the improved cannon. *A′*,*A″*,*A‴*, represent the segments of the barrel, one of which is shewn detached at figs. 4, 5, and 6. The segments are of a spiral shape, with a conical exterior surface, and a polygonal spiral shape in the interior; they taper from the breech to the muzzle, being thicker and stronger at the breech ends; each end is provided with a screw, screwed to receive respectively the breech piece, *B*, and the muzzle hoop, *C*, which have corresponding threads cut in their interior. *C′*, *C′*, &c., are the hoops which fit on to the conical surface of the segments (hoop *C″*, carrying the trunnions), and are forced towards the breech piece, *B*, by the action of the screw in the muzzle hoop, *C*, so as to unite the segments, *A′*,*A″*,*A‴*, together, and thus form the barrel of a cannon.

The improved mode of constructing cannons with a cast iron barrel in one piece, having a slit cut through it, is shown in section, fig. 7, in which *A* is the barrel, having a bore similar to that already described, and a slit through one of its angles, which follows the spiral course of the interior. *a* is a thin segment of metal, which is inserted in the slit from the

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Miscellaneous.

Fig. 1.

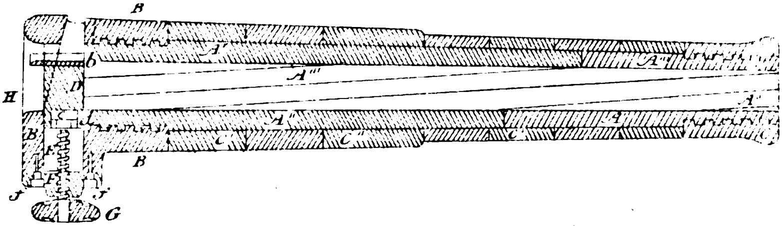

Fig. 2.

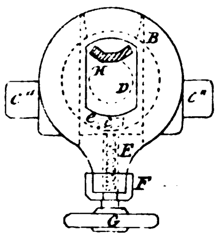

Fig. 3.

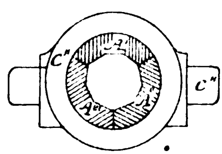

Fig. 7.

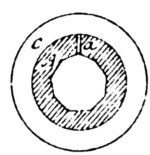

Fig. 4.

Fig. 5.

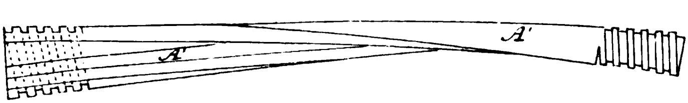

Fig. 6.

Madras Arty: Depôt H.S. W.P.E.

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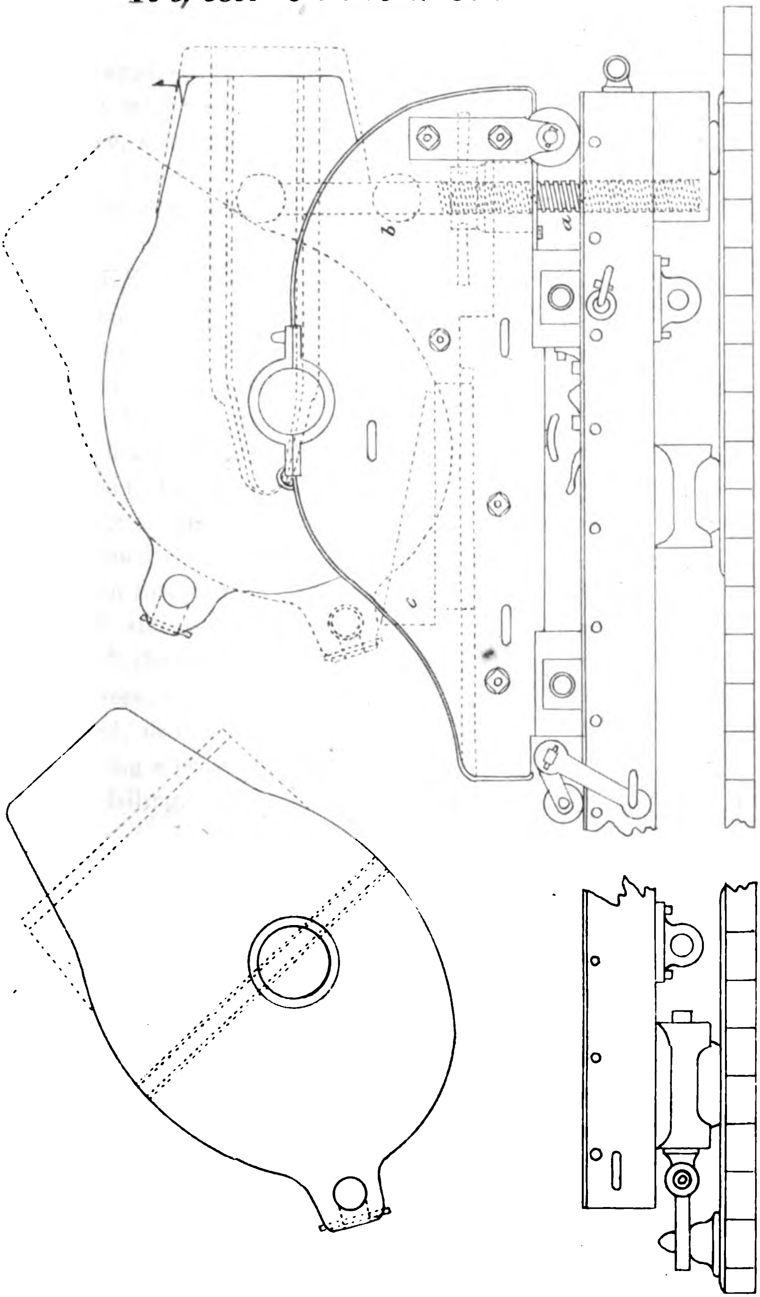
Miscellaneous.

Rifled Ordnance.

Fig. 1.

Fig. 2.



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outside: *C* is one of the hoops, which are similar to those shown in fig. 1.

The improved apparatus for breech loading consists of the wedge piece, *DD*, which takes into a suitable opening or slot in the breech piece, *BB*, and has at its upper end a steel piece, *b*, fitted into it. The side of the wedge piece, *DD*, next to the barrel, has a surface perpendicular to the axis of the barrel, whilst the surface on its opposite side is inclined to it at a small angle. *EE* is a screw of coarse pitch, having a collar, *cc*, at its upper end, which fits into a recess in the wedge piece, *DD*, and is retained therein by the bush, *dd*, and pins, *ee*; the end of screw, *EE*, passes through the nut, *FF*, and has a hand wheel, *GG*, by which it is turned. The nut, *FF*, is fastened to the breech piece, *BB*, by the screws, *ff*. *HH* is an opening formed in the breech piece, *B*, through which the cartridge or charge is passed to the barrel, the wedge piece, *DD*, being previously withdrawn by the screw, *EE*; the wedge piece is then forced up against the inclined edge of the breech piece, *BB*, and its front surface is brought into close fitting contact with the end of the barrel. In its passage upwards, the steel piece, *b*, may be used to cut off the end of the cartridge if desired, or it may be provided with a cutter for that purpose, having a projecting ledge to prevent the powder or dust from falling.

The same principle the patentee applies to rifles. The cross section of the barrel at any part exhibits externally the same polygonal outline as internally, and, viewed longitudinally, has similar spiral lines and surfaces to the interior; it tapers from the breech to the muzzle. The breech piece is screwed on to the end of the barrel, and attached to the stock of the gun by a tail piece and screws. The breech piece has a vertical slot or opening, into which is fitted a wedge piece and screw, as described in the case of the cannon. The cartridge or charge is inserted in the manner described above in treating of the breech-loading of cannon. The fire-arm can-

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not be discharged until the wedge piece is raised to its proper position, as in any other the nipple is too low to be struck by the hammer.*

Rifled Ordnance. A practical Treatise on the application of the Principle of the Rifle to Guns and Mortars of every Calibre. By Δυνάμικος. London: Printed by W. Clowes and Sons, 14, Charing Cross, 1856.

It is a somewhat remarkable fact that, although rifled small arms have been introduced into the armies of all civilized nations, with highly satisfactory results, the adaptation of the rifle principle to ordnance has never, we believe, until the appearance of the work before us, been made the subject of theoretical research and extended experiment. All that has been done in the actual construction of rifled ordnance, in so far, at least, as the amount of turn given to the grooves is concerned, has been almost purely guess-work.

Dunamikos—whoever that veiled philosopher may be—has, however, opened up the subject with becoming boldness, and has obtained, as we gladly observe, permission to dedicate the results of his investigations to the Duke of Cambridge, Commander in chief, a circumstance which will probably obtain for the work the consideration which it well deserves, but which, otherwise, military officers might never have been disposed to concede to it. At the same time, it is proper to state that the author, who is a civilian, is careful not to encroach upon subjects purely military. He says: "To pronounce upon the most proper method of *applying* any fresh discovery affecting that theory (of projectiles) is a subject solely for the consideration of competent military authorities; and if I have ventured to express any opinion on this point, I wish it to be understood, that it is under the correction of those who must be better aware of what is fit or unfit for practical purposes than I can possibly be." This indicates wise subservienee, and will ensure respect for the author.

* Mechanic's Magazine, 18th August 1855.

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The limits of our space will not permit us to do more than notice the principal conclusions at which the author arrives, prefacing these with the remark that the book throughout evidences that the writer is alike capable of experimenting with care, and of applying sound mathematical knowledge, where such is necessary. The latter point is rendered additionally important by the circumstance that treatises upon military subjects are commonly very defective where mathematical investigations are introduced.

One of the chief of the author's conclusions is that the amount of "turn" which it is advisable to give to the grooves of rifled guns, or, in other words, the initial velocity of rotation which it is well to impart to rifled shot, varies according to the form and weight of the shot.

Further, as it is highly desirable, and will ultimately be absolutely necessary, to have a certain standard by which the turn in guns of different calibres may be regulated (hitherto a purely arbitrary matter), the author has instituted, and gives the result of, a series of experiments made in order to ascertain the minimum turn absolutely necessary to effect the desired objects. His conclusion on this point is, that the decrease in the turn of the rifling should, as the size of the shot increases, be as the square root of the number which represents the multiple that the diameter of the one shot is of the other. The arguments employed in reaching this conclusion are carefully detailed, and deserve the closest attention of the reader.

Another point contended for by the author is, that in order to obtain the greatest results, as heavy shells as possible should be used, the limits of their dimensions being about three diameters in length, the shell, of course, having an elongated form, and being fired from howitzers or mortars alone. With such shell the weight of the gun and the charges of powder may be reduced to a minimum.

The inaccuracy of the flight of shot which do not com-

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pletely fill the gun, and in which certain other conditions are not observed, is pointed out; as are also the different curves of flight described by round and elongated shot or shell. The author further shows that accuracy of flight is of much more importance than very great random ranges, and that, since long shot move in curves which much more nearly resemble parabolas than the curves described by round shot, the former may be fired with much greater accuracy than the latter at great elevations.

It should also be stated that, in obtaining the rule above indicated for assigning the turn of the grooves to guns of different calibres, the author has taken for his guide the different effects produced by the air upon corresponding shots, which is, in fact, the only correct method, since it is these effects which alone render the turn necessary.

Besides the more theoretical disquisitions contained in the work, there are several practical improvements suggested. Among these is a method of constructing shot with an expanding ring before the centre of gravity and another behind it, the two rings being expanded simultaneously, so as to keep the axis of the shot coincident with that of the gun in its passage out of the chase; by these means unprecedented accuracy may be obtained in firing long shot.

There is also a method of jointing the trails of field-carriages, by which arrangement all degrees of elevation may be obtained without the use of an elevating screw, thereby allowing field-pieces to be made without trunnions at all.

Although we have done but scant justice to the contents of the work before us, we have said enough to induce military men and others to take it up with interest, believing, as we do, that its perusal will be attended, in some quarters, with important results.*

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* Mechanic's Magazine, 20th December 1856.

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Rifled Ordnance.

To the Editor of the Mechanics' Magazine.

Sir,—I have read with much interest a "Treatise on Rifled Ordnance," by "*Dunamikos*," noticed in your Magazine, a week or two since,* and consider it is very creditable and enterprizing in an individual to undertake experiments in gunnery, involving, as they do, a large expense, and the expenditure of a great deal of time, before results of any value can be obtained. Should his rule for giving the twist to rifle grooves be found even to approximate the truth, he will be entitled to great credit; for its application to small arms has baffled theorists with all their labours of the last five years; and the experiments of the French Government, in lieu of settling the question, have shown it to be most difficult of solution, *quoad* hand-arms at least. I submit a few suggestions which, if of no practical value to the nation at present, may, through the effective aid of "*Dunamikos*," be devolved and proved, or disproved.

Having superintended the erection of steam machinery for producing the rifle used with the hollow elongated ball, and a series of experiments on the form of projectiles; and having had my attention turned, during a number of years, to all the modern improvements, made and attempted, having reference to rifled arms and ordnance, I am led to the conclusion that where range and accuracy are desirable, the rifled cannon will eventually, and at no distant date, supersede the use of the smooth bored gun, both for field service and in batteries, and is therefore worthy the attention of artillerists, both theoretical and practical—the suggestions of the one being verified or condemned by the experiments of the other.

The elongated projectile first suggested by Hutton as a *desideratum*, has but recently attracted the attention of scientific men, although long in use by the Swiss, and in the

* Artillery Records page 627 "Miscellaneous."

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United States, and it has been subjected to various modifications of form, in the hands of De Lavigne, Minié, Pritchett, Greener, and others. By comparison of these balls and their appropriate rifles with the Swiss, I was satisfied that, at and under 800 yards, the latter had the advantage in accuracy, and required less elevation. The objection to it, however, was the difficulty of loading, as the ball required driving down ; and after a few discharges the difficulty increases, as in the rifle in ordinary use. I found, however, that by diminishing the calibre and increasing the length of the ball, that the ball, although as loose as the Pritchett and without any hollow in the rear, took the grooves perfectly, and from being enabled to use a greater charge of powder, and the ball offering less resistance than one of larger calibre and equal weight, the twist required was larger, thus avoiding, in a great measure, the spiral or cork screw motion, known by the French as *derivation* to distinguish it from the motion on its axis called rotation. (This motion is exhibited in the humming top after it leaves the handle and before it *sleeps* on its centre, and will serve to explain many puzzles in the flight, velocity, and direction of oblong projectiles). The curve of flight was parabolic, and a much less accurate knowledge of distance would suffice to ensure its hitting such objects as men, cavalry, &c. The fact is, that the first impact of the gases from the ignited charge, *upsets* the lead at the rear of the ball, before the inertia of the forward end is overcome, and it is forced into the grooves. By diminishing the calibre and increasing the length of the projectiles, I found that larger charges of powder were of course required, but the ball was of simpler construction than the Minié ball; it offered less resistance to the air, its flight more nearly resembled that of the arrow, its initial and mean velocities were greater, and its ricochet more serviceable. By cutting channels around its periphery, the swedging or upsetting can be carried well forward in the substance of the ball, and the ball leaves the muzzle of the rifle a perfectly compact

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mass, showing only the grooves, the channels being obliterated. It may be objected that this ball would not make so bad a wound as the Minié ball. It is true, that it would be more like a punctured wound, but it would go through two instead of one, and when it met with a positive check, such as a large bone would offer, it would turn over and do equal mischief.

The Prussian needle gun was found to have some advantage over other arms of the same calibre, from igniting the powder in front, but this was not considered sufficient to compensate for the disadvantage of carrying fixed ammunition containing fulminate, and the liability of the needle to get out of order. Again, as length of needle was a strong objection, the calibre of needle guns was large, and it could not have the same proportionate advantage as in a smaller bore. But I claim it to be correct in principle, and to be attainable in a more simple manner.

The Government of the United States made experiments with rifled cannon and oblong balls, a few years since, which were totally unsuccessful. Since that time, however, practical men in that country have constructed rifled ordnance, and have lately succeeded in obtaining unparalleled ranges in their experiments with guns loading at the breech. I have witnessed some of these experiments, and have seen their guns and projectiles. One of these guns, constructed at the Novelty Works, New York, was over 20 feet long, 12 or 14 inches diameter at the breech, and its bore of about the calibre of a 6-pounder. It was made intwo pieces, bolted together by flanges in its centre, for convenience of boring and carriage. The projectile used was about five calibres in length, conical at both ends, made of iron, and surrounded by a leaden ring, of one-fourth of its length, cast around its centre, and cast with furrows and bands fitting to those of the bore, and at the same angle of twist. The shot and service charge were inserted at the breech, which was closed

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in their rear by a tapered key, driven down from above with a mallet, through slots in the body of the gun, and having a projecting head extending backwards. The key is raised by means of a short curved crowbar, when a fresh charge is to be introduced. Forward of the breech charge (which is comparatively light) and the shot, are four chambers screwed into it, called by the inventors *accelerators.* They enter the barrel or bore at an angle of perhaps 45° to its line of metal. These chambers are loaded separately, with a small wad of gun-cotton and charge of powder, and closed by keys similar to the one already described. They are placed two on each side, one pair a few inches in advance of the ball, the second pair perhaps a foot or more in advance of the first pair. The first charge, on ignition, overcomes the inertia of the projectile, and its flame ignites the four anterior charges as the ball passes out. The report is a single one, and the initial velocity, penetration, and point blank range obtained by these somewhat complicated appliances, both on the small and large scale, are incredible. With the gun just described, in the first experiments they obtained a range of nearly 5,000 yards, and expected a greater range with increased charges; and I have seen a small ball of about $\frac{50}{100}$ ths. of an inch in calibre driven (by 3 drachms of powder arranged in like manner) from a rifle barrel, through 36 inches of board and 8 inches of brick wall behind it.

From the results before stated, and many others which it is needless to recapitulate, I am led to believe that important results may be obtained from rifled cannon, and that the present system of igniting the charge is incorrect in principle. The method described is defective on account of its complication of parts, the imperfection and weakness of a breech formed by the key and slot, and the difficulty which would occur in removing the keys after a number of discharges. I believe, however, that a gun loading at the muzzle may be constructed in a much simpler manner to attain the same object, by making it of comparatively great length and small

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calibre, and igniting the charge of powder at its forward end nearest the shot, either by placing the vent in that position, or by inserting wires into the body of the gun, and using the electric spark, when the use of that means is rendered certain.

Should your space permit, I will, in my next suggest a mode of constructing wrought iron rifled cannon and their projectiles, which, I think, will be found simple in character, and worthy a trial by those who can afford to indulge in these experiments.*

I am, Sir, yours, &c.

(Signed) W. M. B. Hartley.

16, Bury-street.

The "derivation" of Projectiles.

To the Editor of the Mechanics' Magazine.

Sir,—Your intelligent correspondent, Mr. W. M. B. Hartley, in his interesting letter on rifled ordnance, in your number 1744, has committed an error, I fear, in speaking of "the spiral or corkscrew motion, known by the French as *derivation*."†

On turning to Captain Jervis-White Jervis's "Rifle Musket," a Practical Treatise on the Enfield Pritchett Rifle," page 58 (a treatise which would have been much less defective than it is, had the author been a practised mathematician), I find the author, after describing the motion of an elongated shot, the point of which lies above the line of flight (or trajectory), says:

"The lower side of the projectile, therefore, moving in compressed air, and the upper in rarefied, deviations must ensue. For, as the upper part of the bullet moves from left to right" (by virtue of its rotation about its axis) "the bottom must move from right to left. But the lower resistance to the motion of rotation being produced by the friction of the compressed air, is greater than the upper resistance, which depends on the friction of the rarefied air. By

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* Mechanics' Magazine, 10th January 1857.

† Artillery Records page 631 "Miscellaneous,"

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combining these two resistances, there results *a single force acting from left to right,* which produces what Captain Tamisier termed *derivation.*"

Now, if Captain White be right—and I have independent reason to believe that he is--Mr. Hartley must, I submit, be wrong; for a single force acting in one direction would produce not a spiral motion, but a continuous deviation in one direction.*

I am, Sir, yours, &c.,

January 12, 1857. (Signed) SPECTATOR.

Rifled Ordnance.

In a former number we noticed a work on "Rifled Ordnance" by an anonymous author, published by Clowes and Son, and dedicated to the Duke of Cambridge.† This work has subsequently reached a third edition, containing a large body of new matter, which adds much to its value. We propose to gather from the book in its new form a few suggestions, which appear to us to deserve attention, as the results of much reflection and numerous experiments on the part of the author.

The regulation of the turn of the grooves, whether for rifled ordnance or small arms, must depend, not only upon the description of projectiles employed, but also upon the nature of the service for which they are required. By giving to a shot a quick rotary movement about an axis situated in the direction of its flight, each portion of its surface is presented in turn to the same action of the air in such rapid succession that the latter has not time to act upon one part more than upon another, and its action upon the whole surface of the shot is thus equalized. The velocity of the rotation will, as the shot progresses, gradually be reduced by the resistance of the air; so that in an extended flight it will no longer answer its purpose. The only remedy for this, when the shot has to be

* Mechanic's Magazine 31st January 1857.

† See *Mechanics' Magazine* No. 1741, vol. lxv, p. 586. Artillery Records page 627 "Miscellaneous."

fired at great elevations, is to increase the turn of the grooves. It would, therefore, be necessary to give a greater turn to the grooves of the description of ordnance required for this purpose, than to those which would (as with small arms) always be fired with less elevation. Undoubtedly, the greater the velocity of rotation given to the shot in either case, the more accurate would be its flight; but, as great angular velocity, when acquired by means of grooves in the bore of the gun, is attended with a loss of range, the least possible turn that can be efficiently used the better. Other inconveniences (such as the recoil, and liability of the shot to strip,) have likewise to be taken into consideration, and the length of the turn thus becomes a matter of great importance. It will be impossible to decide upon any standard for this turn, until the description of gun from which the projectile is to be fired, as well as the nature of the projectile itself, is known. These two being ascertained, it will then remain to find the length of turn which will best secure a proper degree of accuracy for the shot, with as little impediment as possible to its range and velocity of flight. For mortars, which are always fired at high elevations, the turn must necessarily be great, as it is indispensable that the shells projected from them should maintain their accuracy of flight to the full extent of their range. On account therefore of the greater turn than usual, a comparatively low initial velocity must be given to the shell, to prevent the danger of its stripping; for this reason, a shell of a longer or heavier description may be used with greater advantage with these than with any other kind of ordnance, less initial velocity being required for these shells than for others of less length. On the other hand, were it requisite to obtain the greatest possible range in a horizontal direction, or with lower elevations, a much less turn would suffice, but a shell of less length must be used, and a higher initial velocity given to it. In this manner, a greater range at the lower elevations may be obtained, and, for a certain distance, a proper degree of accuracy (the conditions of ordinary rifle firing,

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which is rarely practised at elevations exceeding 5° or 6°.) But, at greater elevations, the latter part of the shell's flight will not by any means be so accurate, nor will it in this case exceed the former in its random range, not only on account of the greater mean velocity of the longer shell, but for the reason that, when the turn is insufficient to keep a projectile steady throughout its whole flight, the plane of its resistance becomes greater in proportion as its flight becomes unsteady, and this not only causes deflection, but compels it to suffer a greater resistance from the air. The only advantage arising from the use of a slight turn, and a lighter description of shell, appear to be that, at the shorter ranges it could be used with less elevation, for the longer shell of the same diameter will not bear a charge of powder proportionate to its weight, even supposing the gun would stand it. It will, however, descend to the earth at a less angle, which is almost as great an advantage as that which would arise from the use of a lower elevation.

The above suggestions are stated by the author to show the widely different results produced by giving a shot its initial velocity of rotation by means of a great turn and low velocity, and by means of a high velocity and less turn. The former method is more applicable to heavy ordnance, and the latter to small arms. Care, however, should be taken that neither method be carried to too great an extreme in either arm; for in the one, the range itself would thereby be too much diminished, and in the other, the limit of the range at which a proper degree of accuracy would be attainable.

Having found, from experience, that great uncertainty and difference of opinion exist in respect to the rifling of ordnance, the author very judiciously says, "If at Shoeburyness, or elsewhere, the experiments with rifled guns, or the projectiles to be fired from them were (instead of being made for the purpose of trying certain shot or shells with a particular kind of gun only,) directed to the acquirement of the best description of shell for every different service, and the turn of the

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rifling best adapted to them *in order to procure a standard*, much more important and satisfactory data than are now obtained would be secured. For this purpose eight or ten guns of the same calibre might be rifled, each with a different turn; all experimental shells being made to fit that calibre, they might then be alternately fired from each gun. By these means the different effects produced would lead to satisfactory and conclusive results."

In the employment of artillery, to obtain the utmost effect with the greatest economy of time, labour, and expense, both in its construction and in its use, is a chief consideration. The engraving, Fig. 1, (Plate 40) represents the description of gun with which this end may probably, in the author's judgment, be best attained. It may be called either a mortar or howitzer, as it could be used as either. It is 5 feet 4 inches in length, and of rather greater weight (120 cwt.) than a 10-inch solid shot gun; it has an 8-inch bore only, but will throw a shell of 250 lbs. weight, with a charge of 10 or 12 lbs. of powder. It might be employed equally as a siege gun, or for the deck of a ship or in gun-boat. It is anticipated by the author that as a mortar, besides an enormous increase in range, it would have the advantage in almost every other respect over the ordinary 13-inch mortar (the weight of which it would not much exceed,*) and could also be used with very great effect horizontally, as it would even then have a greater range than a 10-inch gun, and throw a shell of nearly three times the weight; and, although for short distances, it might require a greater elevation than the 10-inch gun, yet, the mean velocitiy of the flight of such a projectile being so much greater, the mean elevations required for it would be less. It should have one whole turn in 17 feet (though probablyone in 15 feet would be better,) in order to insure a perfectly steady flight throughout. With such a gun as this

* Fig. 2 (Plate 40) shows the respective dimensions of the above gun, and those of a 13-inch sea-service mortar, the latter being indicated by dotted lines.

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(when fired with the above-named chargeof powder and projectile,) a range of 8,000 yards would probably be attainable.

The distribution of metal in this piece of ordnance, and the general construction of it, is said to be the result of some personal experience and a careful consultation of the different data procurable from practical and scientific sources; a slight addition to its length might, the author considers, be desirable (*see* dotted lines, fig. 1,) if bored for a 13-ins. mortar; but as this would increase the weight considerably with a bore 8 ins. in diameter only, it would be a question for military authorities, whether the advantages attending such an addition would compensate for the greater weight. Of course were the gun to be fired at elevations not exceeding 12° or 15°, a reduction in the thickness of the metal at the breech might be made, and its length could, therefore, be increased without materially increasing its weight. It will be seen, that the gun is elevated at the muzzle by means of a screw and roller, *a* and *b*, so that by shifting the quoin *c* at each degree of elevation, the gun is continually supported at three different points. The rest of the carriage is of similar construction to the ordinary gun-carriage used for the heavy deck guns of a ship. If thought preferable, or if the recoil should be considered too great for the foregoing arrangement, it might be mounted somewhat in the manner of a sea service Mortar. It is thought probable, however, that with this weight of gun and low charge (10 or 12lbs.) of powder, the recoil would not be too much (with Fergusson's compressors) to allow of its being mounted as an ordinary deck gun.

This description of ordnance might be employed as a substitute both for sea service mortars and shell guns, when the latter are used in gun boats, so that one description of vessel only would be necessary—the nature of the gun allowing of its being employed for either service, thus combining simplici-

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ty with great effect. The author thinks it would be very desirable to have all guns for elongated projectiles of an uniform character, and (with a view to the employment of the heaviest kind of shell possible,) of a description similar to the above; for whether it be for the destruction of men or of material, this description of shell would always, he considers, prove the most effective; and if they have the disadvantage of requiring a greater elevation, it is fully counterbalanced, in their case, by the angle of the projectile's descent being less.

It appears altogether inexpedient to the author to use rifle guns for the broadside armament of ships or floating batteries; for, what with the delay caused in loading them, if iron shells are used, and the weight of metal required in the gun for expanding shells, they could not be employed with greater general effect than those in ordinary use, especially now that so much perfection seems to have been attained with Moorsom's percussion shells. The same objections would hold good with respect to siege guns for operations on land. For these, such a gun as we have described might prove very serviceable, as it could be used either as a mortar or howitzer, as circumstances might require, and would be much more effective for field service in every respect than another from which a lighter description of shell only could be fired.

"Of course," says the author, very properly, "before so great an alteration in artillery as this could take place, it would be necessary to submit its merits to the severest tests; but I feel assured they must result in the conviction, that it is the proper method for turning this description of projectile to the best account, and for simplifying its use."

It is an important feature in the use of the heavy shells that the length of the bore of the piece from which they are propelled may be considerably reduced; for the velocity which is necessary for them for ordinary purposes can be given with a bore seven or eight of their diameters in length only, and owing to their own great length, they acquire as true a flight

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as they would have if fired from a bore twelve or fourteen diameters long. This the author tried, by gradually reducing the length of an experimental gun from eighteen diameters of the bore to seven. The friction in their passage out of the gun is also much less when its length of bore is reduced. Their want of length, however, would quite preclude the possibility of these being used as broadside guns but on the deck of a large frigate one or more of them would prove a formidable addition to her armament. By the way, the author strongly confirms the view we took in our recent article upon the fighting qualities of the *Niagara* respecting the relative merits of shell guns and guns for firing solid shot. "If I may be allowed an opinion," he says, "I should say that shell guns—that is, such as cannot be used for solid shot as well, should be the exception, and not the rule, both on account of their less range and of the loss of time in loading them. No ship ought, I should imagine, to be armed entirely with them, unless they were of the heaviest kind possible, and she could command very great speed, and so choose her own distance for engaging the enemy."

The improved form of gun above described may also be employed on a smaller scale, as a field howitzer, to throw a shell of 32 lbs weight. In this case it might be mounted on a carriage, with a jointed trail, by means of which the author proposes to increase the attainable elevation of the field piece. On account of the reduced length of the bore, such a gun would be about the same weight as a 9 pounder brass gun, or 24-pounder howitzer. Should it be necessary to use grape shot with it, several plans might be devised for doing so without injuring the grooves, and probably even such as might render it advantageous to use such shot with rifled guns.

We now come to the author's suggestions respecting the projectiles to be used with rifled ordnance. Recognizing the great difficulty that is encountered in endeavouring to

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obtain a shot or shell combining all the necessary qualifications, he lays down the following conditions:—1st.—It is indispensable for a shot to be of a certain density or specific gravity, in order that a proper degree of range may be obtained with it. 2ndly.—Its axis should coincide perfectly with the axis of the bore before leaving the gun, and, therefore, it must completely *fill* the bore, otherwise its flight can never be depended upon; hence the fatal objection to homogeneous shot of a non-expanding metal. 3rdly.—Its centre of gravity should be thrown forward before its centre of figure, in order to give it more stability, and less inclination to turn over. This will allow of the use of a less turn in the rifling, which is an important object in guns of large calibre. 4thly.—Assuming the necessity of employing a compound shot or shell, an even expansion of that portion of the shot which is to take the grooves is absolutely necessary; for unless the axis of the shot be made to coincide exactly with the axis of the bore immediately upon its receiving the impulse from the powder, the chief advantages attending the expansion will be completely neutralized. Lastly.—It should be of a form offering as little resistance to the air as possible. These appear to be the chief requisites for projectiles generally, which are to be used with rifled cannon. It would be preposterous, he says, to deny the advantages of homogeneous shot; but they are wanting in one of the above qualifications, and this unfortunately is the most important with rifled guns; for it would be impossible to obtain any very great degree of accuracy (which, in fact, ought to be one of the chief advantages gained by the employment of rifled cannon), where this property (that of completely filling the bore) is wanting in a shot.

After repeated experiments extended over some months, made for the purpose of obtaining a shell in which should be combined all the necessary qualifications in a manner adapted for practical use, the author arrived at the form of shell

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shown in figure. 3, which in this instance is three diameters long, but may be altered to any length, greater or less. The

Fig. 3.

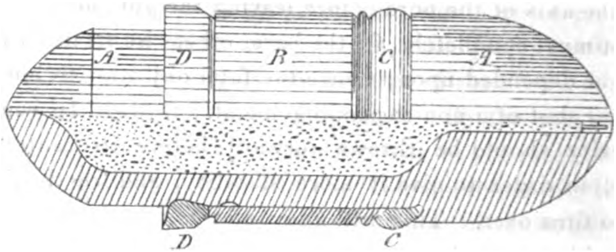

figure is half in longitudinal section, and half in external view. *A* is the body of the shell of cast iron; *B* an iron ferrule or ring, which is sufficiently loose to be moved up or down the body of the shell with facility. *C* is a ring of lead cast on to the shell, and dove tailed on the body in two or three places. *D* is another ring of lead, or other suitable metal, also cast on to the body of the shell. The hinder part of the shell is formed in the manner shewn in the engraving, with the view of throwing the centre of gravity as far forward as possible, as well as to allow of the use of a fuze, and for other reasons, which would take up too much space to explain fully, as they are connected with a variety of experiments.

The principal feature in this shell is the ferrule or iron ring. In making experiments with shot more than two diameters in length, a difficulty was found in procuring with them an expansion sufficient even to cause their axis to coincide with the axis of the bore of gun, unless by adopting means unsuitable for practical purposes. After many attempts, the author at length succeeded in effecting the object by means of the ferrule, *B*, which acts in the following manner. Upon the explosion of the powder, the lower ring,

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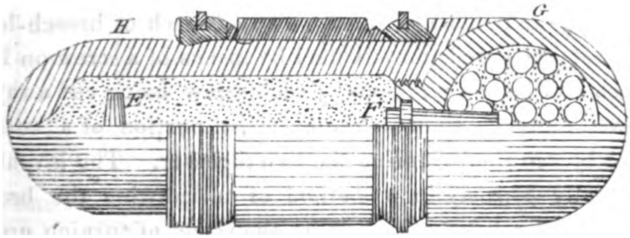
D, is caused to expand and fill the grooves, and at the same moment is driven, together with the iron ring, *B*, in a forward direction; the latter acting as a wedge upon the top ring, *C*, causes it to expand sufficiently to fill the bore, thereby occasioning a simultaneous expansion at two points. The first effect, therefore, of the explosion of the powder upon the shot is to force its axis to coincide with the axis of the bore; it then drives it out in a perfectly straight direction. The freedom of expansion allowed to the powder by the formation of the hind part of the shell permits the first action to be accomplished before the whole body of the shell is sensibly moved from its place.

Fig. 4 represents a half longitudinal section and half external view of a double shell. It is similar in form to the

Fig. 4.



one just described, the principle of its construction being in every respect the same, except that instead of being a percussion shell it is fired with a fuze, *E*, by means of which (after passing over a certain distance) the hind part, *H*, is blown to pieces, at the same time freeing the top part, *G*, and lighting the fuze, *F*. The top part, or round shell, *G*, continues its flight according to the length of the fuze, when a second explosion takes place.* This shell would doubtless prove very

* It should be understood in this, as in all other parts of the work before us, where a description of any particular kind of projectile or mechanical contrivance

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destructive, when used against large bodies of troops, and when employed against shipping.

We must not conclude these remarks without adding that the work under notice contains much in the way of investigation and discussion, at which we have not even hinted; and although we are far from endorsing all that the writer states, we are confident that the book is well worth serious examination, and capable of affording valuable information to professional men.*

The American Breech-loading Guns purchased by the Government.

A discussion recently took place in the House of Lords respecting the purchase of certain American breech-loading guns by our Government, about which very little seems to be known. The following information will therefore be of interest to the public.

In 1853 an American gentleman, Mr. Eastman, obtained a patent for an invention, in which the breech of breech-loading guns is secured to the barrel by means of a screw on both breech and barrel, portions of each screw being cut away to allow the breech to enter the barrel, a portion of a turn of of the breech then securing the two together. The invention essentially consists in a method of unscrewing the breech from the barrel and withdrawing the same, of turning up the breech so as to bring its chamber into a vertical position

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is given, the author has simply chosen those for description which were found to answer the best (amongst many others) in his own experiments; and with the view, rather of illustrating certain principles, and at least one method of carrying them into practice, than of recommending for adoption any individual shot or shell, of the identical form represented (which, provided the same conditions are observed, may be modified to any suitable extent); "For I am fully aware," he says, "that many things of this nature (although giving excellent results in experiments) frequently require to undergo considerable modifications, before they can be rendered in every respect fit for actual service. The true principles, however, of an art or science being once understood, and the effect produced by certain combinations clearly ascertained, the discovery of the most suitable mechanical means to be employed in carrying them out, will soon follow."

* Mechanics' Magazine 11th and 18th July 1857.

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The American Breech-Loading Guns Purchased by the Government.

Fig. 1.

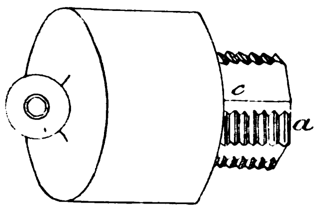


Fig. 2.

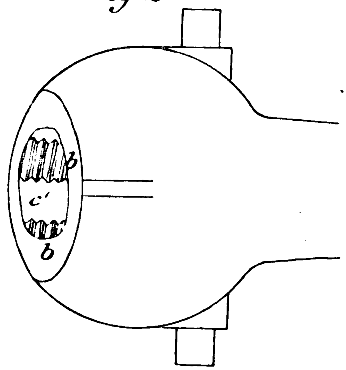


Fig. 3.

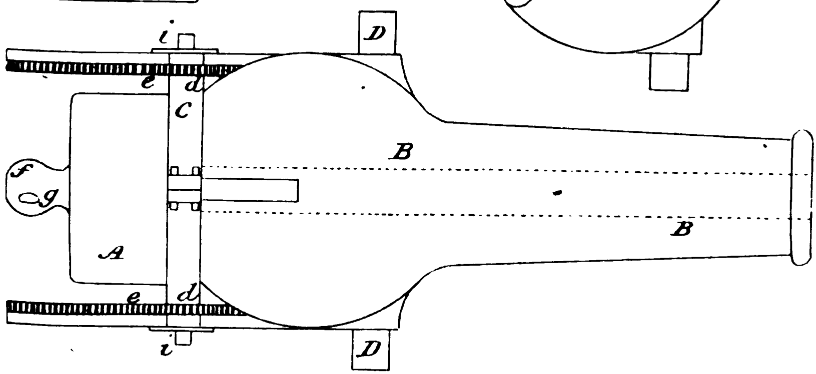


Fig. 4.

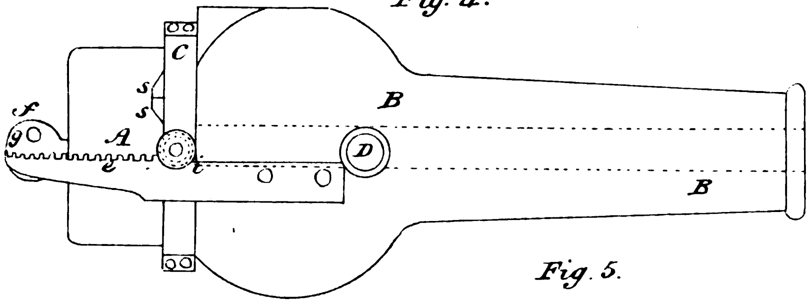
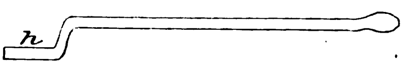


Fig. 5.



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for loading, and then returning the breech into the barrel and locking the two together, these motions being performed through the intervention of appropriate cams, catches, and springs, by the motion of a single lever worked by the hand of the gunner.

His invention embraces a very important application of the arrangement of screw-threads by which the breech and barrel are connected. This consists in placing the joint before the charge, so that the breech-piece really becomes a piece of Ordnance in itself. The difficulty experienced in obtaining a tight joint in ordinary breech-loading guns is thus got rid of, for the gases generated by the explosion of the charge do not reach the joint until their expansive force has been very considerably reduced. This result is of the first importance, and constitutes the basis of all the other improvements of the inventor.

The six guns which have recently been landed at Woolwich Arsenal, and which were the subject of the conversation in the House of Lords, are constructed with this improvement, but the cams, catches, and springs, &c., are dispensed with, and motion is communicated to the parts as follows: the partial rotation, by which the threads of the breech are turned clear of those in the barrel, is effected by a handspike or lever passed through a hole in the cascable; the withdrawal of the breech is produced by means of racks and pinions, placed one on each side of the gun; and the elevation of the fore-end of the breech to receive the charge is produced by the handspike in the cascable, the breech being very nearly balanced on the pinions or rollers at the side, and therefore easily moved from a horizontal to a vertical position. The reverse operations restore the breech, when charged, to its place in the barrel. These arrangements have been adopted in the guns now at Woolwich on account of their extraordinary size, their weight being 16½ tons.

The committee of Officers, whose duty it is to test and

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report upon improved ordnance, have not completed their experiments with the guns in question, but we are informed that results of a very extraordinary character were long since obtained with guns essentially of the same kind, and were deemed so satisfactory that Lord Panmure remunerated the inventor and purchased his patent, although, with a clumsiness which is but too common in Public Departments, the renumeration was made to appear as if it were paid simply for the purchase of the patent, whereas it was of course intended in part to reimburse the inventor for his pecuniary outlay, and in part to compensate him for the labour expended in the introduction of his invention, and the establishment of its merits. We mention this, because the manner in which the expenditure is formally recorded affords room for unnecessary cavil, and, indeed, might occasion much misapprehension even in the minds of persons well affected towards the Government.

We will now describe the guns at Woolwich more fully by the aid of the annexed engravings. (Plate 41.)

If a male screw, *a*, fig. 1, is cut upon the end of the breech, and a corresponding female screw, *b*, fig. 2, is made on the interior of the barrel, and these screws are then marked off into six sections, and the threads upon every alternate section in each are cut away, as at *c c′*, it will be evident, that by turning the breech so that those sections, *a*, of the male screw upon which the threads remain stand opposite to the sections, *c′*, of the female screw from which the threads have been cut away, the breech may be readily slipped into the barrel.* If now the breech be made to perform a sixth of a revolution, those sections, *a*, of the male screw upon which the threads remain will engage with the screw sections, *b*, of the female screw, and the two parts

* Figs. 1 and 2 are intended to illustrate the internal arrangement only, and are not by any means designed to represent the proportions of the parts.

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will be drawn firmly and tightly together. This explanation is sufficient to show how the breech and barrel are connected.

Fig. 3 is a plan view, and fig. 4 a side elevation of one of the guns as seen at Woolwich. *A* is the breech; *B*, the barrel or body of the gun; *C*, a collar round the breech; *D*, the trunnions. The collar, *C*, has connected to it the pinions, *d d*, which run on the racks, *e e*, these latter being connected firmly to the sides of the gun. The breech, *A*, revolves through a portion of a revolution within the collar, *C*, its motion being limited by the stops, *s s*. *f* is the cascable, which has formed in it the hole, *g*, to receive the end, *h*, of the lever shown in fig. 5. *i i*, are studs or centres, on the pinions, *d d*, to receive spanners or levers, by which the pinions are moved along the racks, *e e*. The action is as follows: Supposing the piece to have been discharged, the lever, fig. 5, is placed in the hole, *g*, of the cascable, and the breech, *A*, thereby rotated through the necessary distance to disengage the threads. The pinions, *d d*, are next put in motion, and the breech, *A*, thereby carried back clear of the barrel, *B*. The rear end of the breech is finally depressed, so that the fore-end is carried up clear of the barrel to allow the charge to be inserted. This being done, the operations are reversed, and the piece thus prepared for firing.

The entire weight of one of the guns is, as we have said, 16½ tons. The breech alone weighs 5 tons, but is nevertheless easily and rapidly worked by four men. The length of the bore is 12 feet, and the diameters of three of them 8½ inches, and of the other three 6½ inches. They are all rifled with five grooves of the same breadth as the stops between them. They are made from the finest American charcoal iron, and so constructed that the bore may be greatly enlarged, for experimental purposes, at a small expense. The shot to be fired from them are elongated, and weigh 170 lbs. each. We hope to give before long the results of the trials

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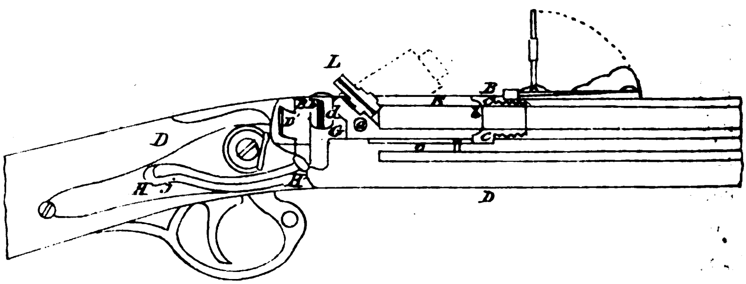
shortly to be made with these guns; in the meantime we may state, that it is anticipated that the range and penetration obtained with them will exceed those obtained with ordinary cannon as much as the range and penetration of the Minié rifle shot exceed those of the ordinary musket bullet.*

Captain Harrison's patent breech-loading Fire-arms.

CAPTAIN G. A. HARRISON, of H. M. 79th Highlanders, has patented an excellent arrangement of the parts of breech-loading fire-arms, represented in the accompanying engravings. Fig. 1 is a view partly in section of as much

Fig. 1.



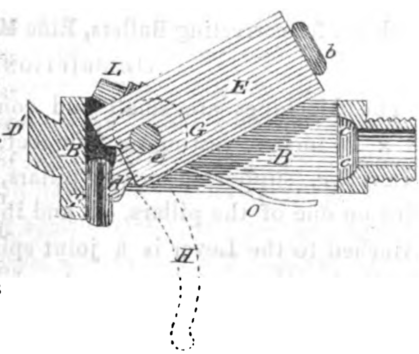
of a musket as is sufficient to exhibit the improvements, and fig. 2 is a view partly in section of the breech case and breech bolt. The moveable breech-piece, *E*, is fitted in a recess at the rear of the barrel, and is capable of backward, forward, and rising motions. The fore-end of the breech-piece, *E*, terminates in a tapered projection, *b*, which slides into and out of a similarly formed recess, *c*, in the rear end of the barrel. The rear of the breech-piece, *E*, is provided with an ordinary nipple, *L*, for the reception of a percussion cap, which is fired by a hammer and an ordinary lock. The breech-piece, *E*, is drawn back by a lever, *H*, which at the

* Mechanics' Magazine, 25th July 1857.

same moment frees a metal wedge, *F*, at the back thereof. When the breech-piece, *E*, has been drawn back sufficiently to release the tapered end, *b*, from the barrel, on the lever, *H*, being further drawn back, a spring, *o*, raises the fore-end of the breech chamber (as shown in fig. 2, and in dotted lines in fig. 1), and the same is kept raised by the spring, and in this position the chamber is prepared for the reception of its charge. After the charge has been inserted, the fore-end of the breech-piece is depressed by the finger or thumb, when the lever, *H*, is returned to its seat; and in being so returned it simultaneously pushes the breech-piece, *E*, forward until the tapered end, *b*, is engaged and driven home into the rear end, *c*, of the barrel, and brings up the metal wedge, *F*, at the back of the breech-piece, and before the rear end of the casing, *E*, and thus a solid abutment is obtained to resist the effect of the discharge. Should any wear take place in the tapered surfaces at the front of the breech-piece, the wedge, *F*, at the back, will compensate for the same and always keep it tight.

D is the stock in which the barrel is secured by keepers and by a hooked projection, *D′*, formed on the rear end of the breech-case, *B*. This hooked projection takes into a hole or recess formed in the ordinary manner in a piece of metal which is set in, and secured permanently to the stock. The breech-piece, *E*, is formed as shown at *b*, and takes into a recess of a corresponding

Fig. 2.



shape formed in the breech-case, *B*, at *c*. When charged, the tapered end of the breech-piece is held hard into its recess by a wedge or key, *F*, which key is jammed into the position in Fig. 2. The key, *F*, when acted upon by the lever, *H*, is jammed by a projection, *d*, on a disc or boss, *G*, which is sunk into the breech-piece, and is secured on a spindle, *e*, and turned by the lever, *H*, the projection takes into and between two teeth formed in the farther edge of the wedge, *F*, so that as the disc and projection are partially rotated, its effect will be to raise or lower the wedge, *F*, according to the direction in which the lever, spindle, and disc are turned. The disc, *g*, has a square hole formed in it, which fits on a square portion of the spindle, *e*, so that when the lever and spindle are turned, the disc is carried along with them; it likewise allows the lever and spindle to be withdrawn from the disc when necessary, and thus releases the breech-piece, and leaves it free to be withdrawn. Sufficient spring is given to the lever, *H*, so that when it is pressed up and held by the pin-catch, *j*, the wedge will always keep the tapered end of the breech properly in its recess, and prevent the escape of gas, and likewise compensate for any slight amount of wear that may take plaçe.*

Machines for correcting Bullets, Rifle Musket Bore ·577, Plate 42.

Description.

The Machines are small and convenient for use, bed *a* 18 × 7½ inches, resting on four feet, *b*, they are worked by a Lever, *c*, supported on two pillars, *d*, *e*, and working in a joint on one of the pillars, *d*, and in a slot on the other, *e*. Attached to the Lever is a joint spindle, *f*, into the end of which the plug, *g*, is screwed and which works through a bridge, *h*, secured to the bed. The Die, *i*, is made of steel, and is left dead hard, the exterior being slightly conical.

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* Mechanics' Magazine, 25th July 1857.

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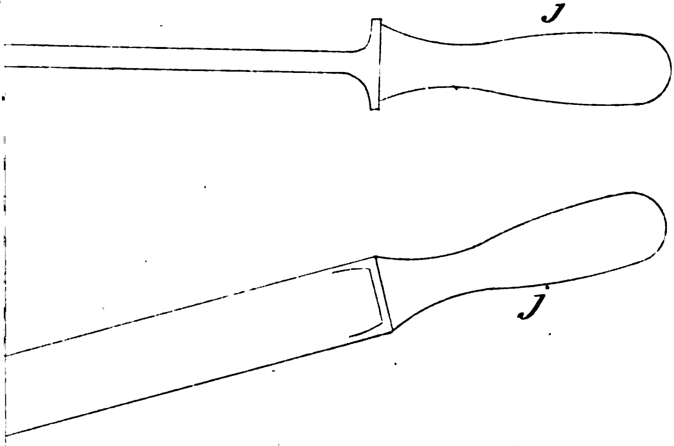
shket Bore ·577.



The Lever. *c*, is provided with a handle, *j*, which is worked with the hand and the machine also fed by the hand. The Lever, *c*, is raised sufficiently to admit a bullet—it is then pressed down, and the Plug, *g*, descends into the cup of the bullet, forcing it nearly through the Die, *i*, the succeeding bullet causing it to drop.

The side of the pillar *e*, shaded, as shewn in the plate is of brass, the remainder of the Machine being of iron.

Elongated Rifle Shot.

To the Editors of the Mechanics Magazine.

Gentlemen,—In a recent treatise on fire-arms, by Lieutenant F. C. Simons, Bengal Artillery, page 25, is the following passage: " The projections upon a bullet are the rudders of it, and determine the direction of its head, and that too much after the manner that the hoisting or lowering particular sails of a ship is often made to determine the direction of its head." I do not think that the projections have this effect; their use is to hold firmly the grooves of the rifle, and not slip out of them, for if they do slip out of the grooves in passing through the barrel, the spiral motion round the long axis of the shot is not imparted to it. The following experiment proves this. In the year 1823, I was in the habit of discharging a rifled arrow or bolt, from Staudenmayer's rifled air-gun, and found that with elevation, I could throw it seven hundred yards. Its flight was perfectly steady, and the line of aim accurate. When I shot the same rifled bolt with its projections vertically, its flight upwards was perfectly steady, having the rotatory of spiral motion imparted to it; but when it began to descend, having no longer the spiral motion, it vibrated greatly. This, I think, proves that the spiral motion was altogether independent of the projections on its inner end. When I shot the same bolt from the smooth bore barrel of Staudenmayer's air-gun,

it barely reached the distance of four hundred yards, and vibrated during its whole flight. This rifled bolt is represented in page, 7, fig. 15 in my pamphlet on projectiles. (Hebert, 88, Cheapside.)*

I am, Gentlemen, yours, &c.,

J. NORTON.

June 30.

Iron and Steel.

At the meeting of the Society of Arts on the 27th of May, Mr. Christopher Binks (who has recently filed the specifications of two patents for "Improvements in the manufacture of iron and steel," and for "Improvements in converting iron into steel, and in giving a coating of steel to iron") read a paper "On some combinations and phenomena that occur among the elements engaged in the manufacture of iron, and in the conversion of iron into steel." The following is an abstract of his remarks:

The broad distinctions that exist in their mechanical or physical properties between steel on the one hand and malleable iron, or cast iron, on the other, would seem to leave room for great doubt that these distinctions are due solely to the absence in the one, and to the presence in the other, of the element carbon, or to the merely minute differences in the relative proportions of that element that are found in steel and in cast iron. Yet this is the received formula of the composition of steel; namely, that it consists solely of about 99 parts of pure iron combined with one part of carbon; and any other matters that, in extremely minute proportions, analysis may have, from time to time, or occasionally, detected in it, have been considered as foreign and accidental only, and in no way essential to, but rather interfering with, its true chemical composition and character.

* Mechanics' Magazine, 11th July 1857.

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In this light, for example, have been looked upon the minute proportions of manganese found in some descriptions of steel, and also the nitrogen developed during analytical operations.

The same chemical doctrine of composition has always influenced, and still influences, the selection of materials to be used as re-agents in the formation of steel, or for the conversion of iron into steel. Hence, it is deemed needful only to bring heated iron in contact with carbon, or with some carbon compound, in order that the iron shall take up the one per cent. or thereabouts, considered as essential to steel; and hence, also, the selection of charcoal as this re-agent principally; and whenever other re-agents may have been taken and used as aids or substitutes, leather shavings, for example, this selection has always been made on the same general principle that it was the carbon alone that was to be absorbed by the metal. It will be seen, however, that either accident alone, or some theory of the quality of the carbon in these specially selected materials, has undesignedly led to the employment of the very elements along with the carbon that the production or the chemical composition of steel demands, and which other elements existing, theory would either have altogether rejected, or certainly never have sought for. But let any one make a pilgrimage to Sheffield, and among the multifarious operations of the converting houses, and of the tool makers, he will speedily discover enough to shake his faith in the old doctrine, and facts enough upon which to reason in search of a new one.

He will perceive, for instance, that the old cementation process, the avowed object of which is to bring it into and keep in contact, highly heated iron and carbon, in order simply to effect a combination between these two, is by no means of the uncomplicated character such simple conditions would imply. He will find, too, among the higher and thinking classes of that busy world, a growing conviction of

the insufficiency of the old theory—a conviction such as that which recently led Mr. Sanderson (one of the highest and most experienced of steel makers) to state, in effect, that "the abstraction from cast metal, containing 5 per cent. of carbon, of fourth-fiths of that quantity, does not necessarily result in the conversion of that iron into steel, and that the abstraction from pig or cast iron of the entire quantity of the carbon proper to cast metal, does not result in the conversion of the cast into malleable iron."* In other words, in this statement of one who is ever surrounded with practical evidences, and habituated to the considerations they lead to, we have it given, as the result of such considerations, that the notion generally entertained is an erroneous one—viz., the notion that steel is merely iron combined with about one per cent of carbon, and that malleable iron is merely iron without any carbon at all, or with less carbon than that requisite to form steel.

Before proceeding further, it is needful to define what steel really is physically, that is, what distinguishing properties it possesses, which, taken independently of its chemical composition, shall constitute an easy and incontrovertible test; or, in other words, shall enable us clearly to distinguish steel proper from iron compounds, or alloys of iron with other metals, or mixtures of iron with non-metallic elements, which in some respects resemble, but are not really steel.

Steel is distinguished from all other compounds by its capability of receiving different degrees of hardness, and a degree of hardness comparatively superior to any other metal; its elasticity under certain kinds of treatment; its capability of receiving a fine and a peculiar polish; its development of certain different colours under different degrees of heat; and by the permanency of the action upon it of induced magnetism. It is distinguished from pure iron by the complete ab-

* See *Mechanics Magazine*, vol lxv, No. 1725, p. 204, col. 2.

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sence in the latter of any one, or degrees of any one, of the properties just enumerated. But there are compounds of iron that exhibit some, but not the whole, of the special properties of steel. The outer coating of common cast iron, when "chilled," or when the casting has been made in sand, is often as hard and as untouchable by the file as the best tempered steel itself. There exist also alloys of iron (as of iron with manganese and with other metals, such as those that were investigated by Stoddart and Farady), that in the property of hardness alone are scarcely inferior to the finest steel. But in none of these special compounds are there associated the whole of the peculiar physical properties, the collection or series of which distinguish steel from any other substance. The peculiar effects of an admixture with steel, or with pure iron, of phosphorus, sulphur, silicium, &c., are pretty well understood; but it is the varieties of steel, the results of admixtures with steel proper of non converted iron, in various proportions, that constitute the real difficulties of discrimination, and for these there exists no special test.

By means of a number of experiments with various reagents the author found:—

1. That heated iron, exposed to the action of pure carbon, and kept out of reach of contact with any other element, is not converted into steel. A small rod of malleable iron packed in boxwood charcoal in a closed porcelain tube, and kept at a full red heat for 12 hours, did not, after being tempered, show a hard steel surface, nor did it exhibit, under high and different degrees of heat, the play of colours peculiar to real steel. It still remained malleable iron.

2. But that, when atmospheric air is admitted to such an arrangement in such quantity only as still to keep the carbon in excess, then, in the first instance, the surface of the iron, and, finally (if the time of contact be long enough), the whole of the iron, is converted into steel.

3. That the application to the iron of gaseous nitrogen does not produce steel.

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4. That neither does the application of carbonic oxide give steel.

5. That the application to the iron of a hydro-carbon (as when olefiant gas is passed through the tube, or when the red-hot rod is dipped into oil containing no nitrogen) does not produce steel.

6. But that the application of olefiant gas mixed with ammonia, or the application of gaseous cyanogen, produces steel, as does also the dipping of the hot metal into a nitrogenised oil or fat.

7. That the application of ferrocyanide of potassium (as has been so long known) gives steel.

8. That, equally with the ferrocyanide, does the application of the simple cyanide of potassium result in the production of steel; therefore, it is not to the iron contained in the ferrocyanide that the steel making property of the latter salt is due.

9. That potash applied to the hot iron, or keeping the hot iron in contact with the vapour of potassium, does not yield steel.

10. That with iron of the kind that has so far been referred to and used, that is, commercially pure wrought iron, containing no material proportion of carbon, the application to it of ammonia, or of nitrate of ammonia, fails to produce steel.

11. But that the application of ammonia, or its muriate, to iron containing a considerable proportion of carbon, results in its conversion into steel.*

* These results tabulated, and the composition of the re-agents expressed in formulæ, will better exhibit the inevitable deductions to which they lead.

(1). $Fe + C$ (in excess), every other element excluded.......Leaves iron.
(2). $Fe + C$ (in excess) + (atmospheric air)................Gives steel.
(3). $Fe + N$ (gaseous nitrogen)...........................Leaves iron.
(4). $Fe + CO$ (gaseous carbonic oxide)....................Leaves iron.
(5). $Fe + H_4C_4$ (olefiant gas)..........................Leaves iron.

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By a consideration of these preliminary and merely guiding trials, besides the other deductions they lead to, as already stated, there is made apparent one significant fact, namely, the invariable co-operation, so far as these trials extend, of both nitrogen and carbon in the production of steel ; but these co-operate in some manner yet to be defined and ascertained. It still remains to be determined if this cooperation of nitrogen be a *necessity* in steel making ; or if the apparent invariableness of its presence and co-operation will, on a more extended examination, be borne out by the evidence of every other process ; and if so, is it that the nitrogen, conjointly with the carbon, forms some combination with the iron and remains there, or that the nitrogen acts merely as an intermediate agent, and that it still remains a chemical agent, and that steel is merely iron combined with carbon only, though nitrogen plays an essential part in effecting that combination ? But whatsoever may be the functions in steel-making that are exercised by nitrogen, if its office be functional at all, and its presence be not a mere coincidence in every case—the fact of its invariable co-existence with carbon, whenever steel is produced, is incontrovertible.

A review of the above facts and phenomena is provokingly suggestive that the existing theory of the composition of steel is a wrong one. And the first suspicion is that this nitrogen element does actually enter into and exist in that

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(6). $Fe + H_4C_4$ (in excess) $+ NH_3$ (ammonia)..............Gives steel.

(7). $Fe + NC_2$ (cyanogen)..................................Gives steel.

(8). $Fe + K_2, Fe\,Cy_3$ (ferrocyanide of potassium)........Gives steel.

(9). $Fe + K, Cy$ (cyanide of potassium)....................Gives steel.

(10). $Fe + K\,O$ (potash)..................................Leaves iron.

(11). $Fe + K$ (potassium)..................................Leaves iron.

(12). $Fe + NH_3$ (ammonia)................................Leaves iron.

(13). $Fe + NH_3\,Cl$ (sal ammoniac)........................Leaves iron.

(14). $\frac{Fe + C}{95 \quad 5} + NH_3$ (ammonia)...........................Gives steel.

(15). $\frac{Fe + C}{95 \quad 5} + NH_3$ (sal ammoniac)......................Gives steel.

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compound, and that not to errors in analysis, but to misconceptions when nitrogen was found in steel, or to the influence of pre-conceived notions, is to be attributed the fact of this element exercising any kind of agency in steel-making having hitherto been overlooked; or that its presence, when found, has either been disputed or attempted to be accounted for on other grounds than that of chemical combination.

The attention of the chemical world was first prominently called to the fact of the existence of nitrogen in iron and steel by Professor Schafhäutl, a translation of whose paper appears in the *Philosophical Magazine* for 1840. But neither Schafhäutl nor Marchand speculated as to the meaning or the effect of the presence of the nitrogen in steel; wherever in the exercise of their manipulatory skill it is found, the fact is left without comment or consideration.

Now, suspecting less from such evidences or suggestions as theirs than from the facts to be observed on conversion (such as that of the singular influence of cyanogen compounds), the substantial and invariable existence of nitrogen in steel, the writer proceeded to arrive at that point as follows: The best malleable iron on the one hand, and by way of comparison with this, the same kind of iron fully converted by the usual process, were taken on trial; the steel was dissolved in very dilute and pure hydrochloric acid, and the carbonaceous flocculent matter that was left, collected, carefully dried, and analysed. The iron was treated in the same manner, and the comparatively very small proportion of carbonaceous residue given by it also examined. And these were compared with the residue obtained also from cast-iron. Effecting the combustion of each of the residues by aid of the soda-lime process, in the usual manner, the following results were obtained :—1. The residue from the malleable iron contained no nitrogen whatever. 2. That from the cast-iron always showed the presence of nitrogen, but in very minute and in variable quantities; an average of results would seem to confirm the analysis of Marchand. 3. In

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the steel residue there was invariably detected a considerable quantity of nitrogen. The analysis of this carbonaceous residue gave C = 0·63, N = 0·24; impurities, 0·13 = 100. The direct analysis of this sample of steel, using the soda-lime process, gave in 100 parts of steel C = 0·68, N = 0·19; that is, every 100 parts of steel contained about $\frac{1}{5}$th per cent of nitrogen associated with about three times its weight of carbon. The proportion of nitrogen in the residue was greater than in the steel itself,—a result proved afterwards to be due to the absorption of nitrogen or the formation of ammonia in the act of drying the residue. The direct analysis of the malleable iron gave no nitrogen whatever—that of the cast-iron only a trace. This steel contains therefore about $\frac{1}{5}$th per cent. of nitrogen, and by other trials good steel always gives about this quantity, but inferior steel much less. It is obvious that the residue is an azotised carbon, out of which fact arise some important considerations. But confining these, for the present, to the cases of the malleable iron and the steel, it would appear that the difference in chemical composition between these two is not less remarkable than the difference between their respective physical properties; but in what precise manner these two elements, carbon and nitrogen, produce these differences, or the form in which they exist together in the steel, we can only as yet conjecture theoretically.

After detailing various synthetical evidences, the author concluded that one fact is ever apparent, namely, the invariable cooperation of both nitrogen and carbon wherever the result is the production of steel.

The conclusions that to the writer appear to be warranted by the previous evidences are:

That the substances whose application to pure iron convert it into steel, all contain nitrogen and carbon, or nitrogen has access to the iron during the operation.

That carbon alone added or applied to pure iron does not convert it into steel.

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That nitrogen alone so added or applied does not produce steel; but that

It is essential that both nitrogen and carbon should be present, and that no case can be adduced of conversion in which both these elements are not present and in contact with the iron.

That nitrogen as well as carbon exists substantially in steel after its conversion; and such presence is the real cause of the distinctive physical properties of steel and of iron, in which latter these elements do not exist.

That presumptively, but not demonstratively, the form of combination is not that of cyanogen (though that compound plays so important a part in conversion), but is that of a triple alloy of iron, carbon, and nitrogen.

That experimental research is yet required to determine the relative proportions of the elements when their union gives pure steel.

We possess other evidence of the use of nitrogen from another and unexpected quarter; it is on record as a practice of the Indian "Wootz" steelmaker that, along with his iron or imperfect steel in his melting crucible he places as his carbon giving material the wood of the *Cassia auriculata*, and covers the whole with the leaves of the *Convolvulus laurifolia*, both vegetable productions rich in azotised matters. These placed in his closed crucible will give an azotised carbon in contact with the metal. And what may have been the origin of this far back practice of the East—this, to us, apparently empirical handicraft of some Indian Artificer? Has it originally been the result of some mere accident or of some induction or deduction; or is it a relic of some state of civilization and of science superior to those of the West? The Sheffield artizan seeks, even up to the present day, that which the Indian artificer had found out ages ago.

It will be distinctly understood that the facts and reactions given by the writer have not yet been extended in manufac-

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turing operations, but they are more than merely experimental.

The value of combinations of carbon and nitrogen in steel making being acknowledged, then, of all such combinations or of elements containing these, it is undoubtedly to the use of the cyanogen compounds that we should resort for all manufacturing purposes; and the time seems not very far distant when these compounds will become some of the most readily obtained and cheapest of chemically manufactured products. It is some years ago now that Mr. Lewis Thompson pointed out how these could be had through the nitrogen of the atmosphere, and thus gave the germ of a branch of manufacture that will grow into vast importance, and for the promulgation of which the world is indebted to this society.*

The operations of the blast furnace suggest methods for the production of those compounds that are of the highest practical value. There are at play here all the elements for the production of cyanogen, of certain cyanides, and thence of other compounds, and the requisite conditions can be superadded for securing these for commercial purposes. That cyanogen was formed in certain zones of the furnace was proved by Bunsen and Playfair. Dr. Clark, of Aberdeen, many years ago, examined a saline product that was found to ooze out of the tuyere holes of a blast furnace in Scotland, and discovered it to be cyanide of potassium. In several places on the Continent, as at Mariazoll, in Styria, for example, we are told by Gmelin, that this product is so abundant as to be sold commercially for galvanic gilding purposes. It is, of course, the product of cyanogen, when combined with the accumulated proportion of potash contained in the fluxing lime-stone. But why not specially add the alkaline element, and combine in the furnace simultaneously the peculiar reducing and converting actions of these compounds with

* Mr. Thompson's paper appears in the "Transactions of the Society of Arts" for the year 1837.

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their special manufacture for other and equally valuable industrial applications of them that are springing up? And this is undoubtedly one of the most important of the directions that the iron manufacture of this country will in future be bound to take.

In the course of a discussion that followed the reading of Mr. Binks's paper, Mr. F. A. Abel, the chemical officer of the Board of Ordnance, said, the arguments and facts upon which Mr. Binks based the assumption that nitrogen was an essential element in steel, and that indeed steel could only be produced by the union of iron with nitrogen in addition to carbon, were entitled to the most deliberate consideration and to the closest investigation. It would be presumptuous, without such investigation, to enter upon their discussion, or to challenge the construction placed by Mr. Binks upon various circumstances alluded to by him. Assuming, however, that steel cannot be obtained without the entrance of a certain quantity of nitrogen into the constitution of the metal, he (Mr. Abel) was curious to learn in what manner Mr. Binks accounted for the production of steel by the decarbonization of finely divided cast, or partially refined iron in closed crucibles, by such means as those proposed by Captain Uchatius, or by fusing together, in a closed crucible, the proper proportions of cast and wrought iron, the former containing only a trace of nitrogen, and the latter none of that element. With reference to the proportion of nitrogen which Mr. Binks had found by analysis to exist in steel, Mr. Abel would venture to observe that it appeared to exceed considerably the quantity which a perusal of M. Marchand's publication "On the determination of Nitrogen in Iron" would lead the reader to suppose as actually existing in cast-iron and steel. It would have been desirable that some description of the precautions adopted by Mr. Binks to exclude errors had been entered into in a paper of such interest and importance, in order to ensure for the results given by him the confidence

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to which doubtless they were entitled. It must be admitted that some great influence appeared to be exerted by the presence of nitrogen in some form or other in the production of steel; and our knowledge of the reactions in the blast furnace would alone lead us to believe that, indirectly, nitrogen was, with reference to the reduction of iron, a very important agent; but if the suggestion thrown out by Mr. Binks, that steel be an alloy of iron with carbon and nitrogen be adopted, the latter element must be viewed in a new light; for it must have become endowed with very active properties if so small a quantity as even Mr. Binks showed to exist in steel could exert so important an influence upon the character of iron, an influence far surpassing that exerted upon iron by similar proportions of elements remarkable for their chemical activity, which were constantly found associated with that metal. A complete elaboration of the views brought forward by Mr. Binks would not therefore fail to be replete with interest, and amply to repay the labours, of the scientific, and doubtless also of the practical investigator.*

Remarks on Colonel P. Anstruther's theory by Colonel J. W. Croggan.

Continued from page 587, "*Miscellaneous.*"

I will not attempt to give a long dissertation on the subject of gravitation, with the rules of which the readers of the "Madras Artillery Records" are supposed to be well acquainted; but the problems given in Hutton's Mathematics to determine the resistance of the air, afford matter for consideration with reference to the subject under review.

I may however observe that a body in vacuo falls in 6 seconds $6^2 \times 16\frac{1}{12} = 579$ feet, and acquires a final velocity of $6 \times 2 \times 16\frac{1}{12} = 193$ feet; that if projected upwards with the same velocity, and through a resisting

* Mechanics Magazine 6th and 20th June 1857.

medium as the air, it will not arrive at the spot from which it fell, but somewhere short of it, the exact distance of which can be ascertained by calculation taking into account various particulars which will be explained.

The velocity of 193 feet is, in consequence of the counteracting influence of gravity and the resistance of the atmosphere, sooner expended than would be the case if only retarded by gravity, and it consequently rises to the reduced distance in less than 6 seconds.

The instant of its arrival there it commences to fall, and the distance to the ground being less than 579 feet, it may be expected to fall in less than 6 seconds; the distance here supposed being small, the body would not meet with much resistance from the atmosphere, and the time of rising and falling together would probably be somewhat less than 12 seconds.

It must be observed that in falling from great heights the resistance of the atmosphere constantly increases to a certain point, so as to prevent any further increase to the velocity, and that with great velocities both in rising and falling the rules for gravitation are quite inapplicable.

Colonel Anstruther knowing well the properties of the trajectory of the projectile according to his system has adopted a series of velocities and spaces, resulting from certain rules; and I question whether he intended the cursory remarks contained in the 2nd paragraph of his treatise for particular observation.

The trajectory described according to his method is deserving of attention, all attempts to determine the correct path of the projectile having hitherto failed.

Although the retardation of gravity as a substitution for the resistance of the atmosphere, applied to a body projected through the air, cannot be correct, yet the results of the system proposed may shew in many cases a near approxi-

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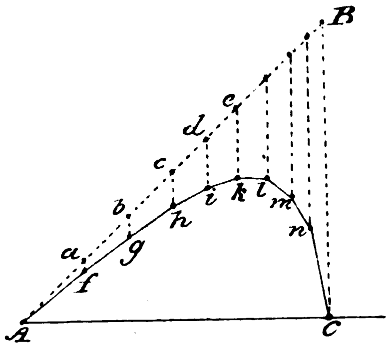
mation to the actual results caused by the resistance of the atmosphere.



Suppose a body projected in the direction AB with a certain velocity, and not affected by gravity, then being only retarded by the resistance of the air it will pass over the unequal spaces Aa, ab, bc, cd, de, &c. to B, the spaces passed over becoming less each second: but while the body is supposed to be passing from A to B it is also drawn downwards each second by the force of gravity as, af, bg, ch. di, ek &c. the body thus acted on by the resistance of the air and gravity describes the curve A, f, g, h, i &c. to C. The great error in the proposed system, which I have pointed out, is making the spaces on the hypothenuse AB to depend on the laws of gravitation, instead of on the rules for determining the resistance of the atmosphere.

It has been shewn by a correspondent of the "Madras Artillery Records"* that the principles of the proposed theory depend on the following circumstances which may be gathered from the 2nd paragraph of the treatise.

1, A ball projected upwards with an initial velocity of 12 S (or 193 feet) will, if unopposed by gravity or the resistance of the air, travel 72 S in 6 seconds.

2. If opposed by gravity and the resistance of the air, it will return to the spot from whence it rose in 6 seconds,

* Page 610, "Miscellaneous."

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3. In 6 seconds by the force of gravity it will fall 36 S.

4. Therefore excluding gravity it will ascend 36 S in 6 seconds, and hence the measure of the resistance of the atmosphere and the proposed theory, which supposes the spaces passed over by a body, when propelled upwards with a certain velocity, to be identical with the spaces caused by the resistance of the air, independent of gravity.

Dr. Hutton has devoted much space and ingenious calculation to prove the height to which a body will rise when projected upwards with a given velocity.

In the first place he has given three tables shewing the resistance of the atmosphere in pounds weight to three balls of different diameters and weights, corresponding to certain velocities, varying from 100 to 2000 feet per second.

And in making his calculations he has taken into account the resistance extracted from these tables, the specific gravity of the air, the specific gravity of the ball, and the decrease in the density of the air as the ball ascends, which makes some difference when calculating for large velocities.

Example 1, A body is projected upwards with a velocity of 2000 feet in a non-resisting medium, or supposing no resistance in the air, and it is found to rise $11\frac{5}{6}$ miles in 62 seconds.

Example 2. Suppose a 24lb. ball projected upwards, as in the last example with a velocity of 2000 feet, to what height will it rise when retarded by the atmosphere, and the answer is 6424 feet, or little more than a mile in $9\frac{1}{2}$ seconds, though found to be nearly 12 miles without the air's resistance.

Agreeably to the foregoing extracts from the treatise the body resisted by both gravity and the atmosphere should rise half the distance, viz. $5\frac{11}{12}$ miles; and the time taken in rising and falling should be 62 seconds; whereas by the 2nd Example it appears that the ball rises only 6424 feet, in $9\frac{1}{2}$

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seconds, and the time of falling 6424 feet being 22 seconds, the time of rising and falling together is $31\frac{1}{2}$ seconds.

The time of rising I find in Hutton's Mathematics, vol. 3, page 286; but as the time of falling 6424 feet is stated by the Revd. J. Richards in his communication to the "Madras Artillery Records"* to be 16 seconds, as extracted from Major Simpson's "Young Officers Assistant Part II." I may as well give an outline of my calculation leaving others to decide which is correct.

To ascertain the time and space of a 24lb. ball descending through the atmosphere—vide Pages 291, 292, Hutton's Mathematics, vol. 3.

Let $g = 16\frac{1}{12}$ feet, the space fallen by a body in one second.

$w =$ 24lb.

$c =$ ·00001725 the ascertained quantity which multiplied by the square of the velocity gives the resistance in pounds.

$v =$ 409 feet being six feet less than the terminal velocity of 415 feet (as extracted from the table), at which the resistance becomes equal to the weight of the shot, as without this small deduction the result would be infinite.

$x =$ the space through which the 24lb. ball falls before it acquires the final velocity,

Then at page 292 I find the following formula.

$$t = \frac{1}{4g}\sqrt{\frac{w}{c}} \times \text{hyperbolic logarithm of } \frac{\sqrt{\frac{w}{c}} + v.}{\sqrt{\frac{w}{c}} - v.}$$

* Page 613, "Miscellaneous."

$$t = \frac{1}{64{\cdot}33}\sqrt{\frac{24}{{\cdot}00001725}} \times h.\,l.\ \frac{\sqrt{\frac{24}{{\cdot}00001725}} + 409}{\sqrt{\frac{24}{{\cdot}00001725}} - 409}$$

$t = 18{\cdot}2357 \times {\cdot}723 = 13{\cdot}18$ seconds being the time in falling before the ball acquires the terminal velocity.

Next to find the space through which the ball descends before it acquires the terminal velocity, (page 291.)

$$x = \frac{w}{4\,g\,c} \times \text{hyp. log.}\ \frac{w}{w - c\,v^2}$$

$$x = \frac{24}{64{\cdot}33 \times {\cdot}00001725} \times \text{hyp. log,}\ \frac{24}{24 - {\cdot}00001725 \times 409^2}$$

$x = 21627\ {\cdot}56 \times {\cdot}128 = 2768{\cdot}3$ feet.

	feet.
Then total height fallen...............	6424
Deduct space as above found.........	2768
The remainder being the space fallen with the terminal velocity.	3656

	seconds.
3656 divided by 415 gives..................	8·81
Time as before found......................	13·18
Total time of falling...	21·99

N. B. To find the hyperbolic logarithm multiply the common logarithm by 2·302585.

The foregoing examples and calculations will at all events serve to shew the intricate nature of the problem; and that as I before stated the hypothenuse of the right angled triangle, or the line of direction of the projectile cannot be calculated by the rules for gravity; there being no analogy whatever between the resistance of the air and gravitation.

J. W. Croggan, Colonel,
Madras Artillery.

St. Thomas' Mount, 13*th August* 1858.

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Sir Francis Knowles' Patent Improvements in the Manufacture of Iron and Steel.

Sir Francis Charles Knowles, Bart., of Lovell-hill, Berks, has patented an invention, which consists of three parts. 1. An improved method of preparing fuel from wood, spent tan, peat, or coal, to be used, or admitting of being used, in the manufacture of iron. For this purpose kilns, ovens, or retorts are constructed of considerable size, capable of containing a large quantity of the raw material to be employed, and admitting of being closed up after being charged. These may be conveniently constructed of fire-brick of any form or material; but must be such as to admit of a pipe, or flues, for the introduction of the heated gases to be presently described, and of other pipes or flues for the exit of the various liquid products of the consequent dry distillation, and of the gases which will thereby be evolved, and to provide for the proper collection of the same by passing them through such hydraulic and other pipes as are used in gas works, or some convenient modification thereof, and for their subsequent cooling, condensation, purification (if required), and collection in appropriate vessels, receptacles, and gasometers respectively. To the pipes, both of entrance and of exit, are adapted cocks or taps whereby the current of the gases and other products may be cut off or diverted at pleasure while the charcoal or the coke is cooling, or being discharged, or otherwise, and a series of kilns, ovens, or retorts, are employed as usual, so that some may be in work while others are out. The kilns, ovens, or retorts, being thus constructed and charged with the raw material, and the entrance pipes or flues and the exit also being open, the patentee introduces through the former the heated gases collected from the top of the blast furnace by any of the modes in use, which gases issue at a heat of about 1,600 deg. Fahr., and the current of these gases is allowed to pass through the kilns, ovens, or retorts moderately at first, until the fuel is dried, afterwards in full force, and thence into

and through the hydraulic pipes to the reservoirs, purifiers, condensers, and gasometers. The furnace gases being incapable of supporting any combustion, act merely by their heat in producing the requisite dry distillation, and pass away afterwards mixed with the gases cooled during the operation; but, after being cooled, purified (if need be) and collected in gasometers, they form a fuel of great power, applicable in all the subsequent stages of manufacture, and dispensing entirely with the further use of coal. The second part of the invention consists of a kiln or a furnace for the conversion of cast-iron into malleable iron or steel. This is constructed of fire-brick or other refractory materials, and it may be cylindrical, square, prismatic, or of a truncated, conical, or pyramidal form. It is furnished with a tap hole like other furnaces, but the essence of this part of the invention is the adaptation of pipes in the interior of the furnace or kiln, which commencing at the top thereof, descend nearly to the bottom, where they are open so as to admit of the metal rising within them when the furnace is filled with it in its hot and liquid state. These pipes are to be made of good fire clay, or some very refractory material, and to their tops are to be fitted closely the blast-pipes of the blowing engine. When it is desired to refine or convert the metal, the metal is first let into the kiln or furnace as hot as possible, and this rising to the same level in the pipes and in the furnace, the blast of adequate pressure is turned on, and the same is forced through the surface of the metal downwards, which is refined thereby in the usual way to any required degree, whether for steel or for iron, according to the time of the operation. The third part of the invention consists in the blowing or forcing of pure hydrogen gas, or of carburetted hydrogen gas, either pure or mixed as before described with the blast furnace gases and purified into the melted metal in any direction whatever, so that the metal and the gas may be thoroughly agitated together. The effect is to purify the metal from sulphur and phosphorus; and

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further, in the case of the carburetted gases to give carbon to the metal, in case, in the making of steel, the previous operation of decarbonization should have been carried too far for the particular quality of steel sought to be produced.*

Remarks on the Ordnance used in the Siege of Sebastopol.

Adjutant General's Office,
Royal Artillery,
Woolwich, 13th May, 1856.

CIRCULAR MEMORANDUM.

The following remarks on the Ordnance used in the Siege of Sebastopol are promulgated for the information of the Royal Regiment of Artillery.

By Command,
H. FALLISER,
Assistant-Adjutant-General.

13-inch Mortars.

35 Land Service 13-inch Mortars were in use during the Siege—one of these which was of the old chambered pattern burst, it was fired at the time with the full charge of 9 lbs., and had stood the same for several rounds. No date can be found on this Mortar, the only marks being L.M. /|\ and 99: and the weight 38 cwt. 2 qrs. 21 lbs. in front of the vent. One was rendered unserviceable by being struck in the muzzle by one of the enemy's shell—3 were rendered unserviceable by the bursting in their muzzles of shells borrowed from the French and fired with English Fuzes of upwards of 50 years old.

All, with the exception of the one which burst, were continued in use till the end of the siege.

The vents of these Mortars have not suffered from the rapid and continued fire to which they were subjected.

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* Mechanics' Magazine, 20th June 1857.

One Mortar is defective in the metal, a small hole about $1\frac{1}{2}$ inches deep and $\frac{1}{2}$ inch in diameter having formed in the bottom of the chamber. This appears to have been the result of age and neglect previous to its being landed in the Crimea. This Mortar was never used except when absolutely necessary to keep up a very heavy fire, the only marks on it are the weight, 38 cwt. 3 qrs. 6 lbs., and 26 on the trunnion.

The total number of 13-inch shells used was 39,345. There having been only 34 13-inch Mortars in use altogether, many of which have only been in position for a few months, those first in position must have fired between two and three thousand rounds; yet *no* Mortar has become unserviceable from heavy fire.

The charges generally in use for these Mortars varied from 4 to 7 lbs., some however have occasionally been used in firing at the shipping with charges as high as 9 lbs.

13-*inch Sea-Service Mortars, with Old Pattern Beds.*

There were 4 13-inch Sea-Service Mortars of 83 cwt. with wooden beds of the old pattern. These Mortars were fired continually and rapidly from the April bombardment till the end of the siege, with charges varying from 10 to 16 lbs. These Mortars have not suffered either in the metal or vent although their beds are much shaken.

13-*inch Sea-Service Mortars, with New Pivot Beds.*

Two other Sea-Service Mortars with the new pattern pivot beds, were sent out, but owing to the difficulty of laying the beds these Mortars were never got into position.

10-*inch Mortars.*

35 10-inch Mortars were in use—one was rendered unserviceable by being struck in the muzzle by the enemy—two burst, both of these were of the old chambered pattern, one of them had no distinguishing mark, but appears from its shape and the state of the metal to have been very old.

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The other Mortar was marked 120 on the trunnion, and 15 cwt. /|\ in front of the vent, and from its appearance seemed to be a very old Mortar. At the time of the bursting of these Mortars, they were both being fired with charges under 4 lbs.

4 of these Mortars were rendered unserviceable by the bursting of shells in their muzzles, the fuzes used being very old.

These Mortars were also continued in use till the end of the siege, with the exception of the two which burst.

The total number of 10-inch Mortar Shells fired was 37,345. As only 17 of these Mortars were in use up to the 17th of June, those first in position must have fired upwards of 1,700 rounds; some must have fired considerably more than this, but neither the vents nor metal appear to have suffered materially in any case.

These Mortars were fired with charges varying from 2 to 4 lbs.

8-*inch Mortars.*

10 8-inch Mortars were in use during the siege. The total number of rounds expended was 3,174, but only 4 of these Mortars were ever much in use, and none of them have become unserviceable.

Coehorn Mortars.

Of the $5\frac{1}{2}$-inch Coehorn Mortars in use only 8 were much fired from. The total number of rounds fired was 4,847. None of these Mortars are unserviceable.

68-*Pounders, 95 cwt.*

7 68-Pounders of 95 cwt. were in use in the English batteries, two of which are still serviceable.

Two burst, one of them in consequence of a shell from the enemy exploding in its muzzle at the instant it was fireed, the other from having been fired (by the Naval Brigade) at at a high elevation after having fired over 2,000 rounds.

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The 3rd unserviceable gun was struck thirteen times by the enemy and split in the muzzle, but was used with an iron band round the muzzle, and on losing a trunnion was sunk in the ground and fired at a high elevation and has not burst.

The total number of rounds fired by these 5 Guns was 4,649 solid shot; the exact number of shells is unknown, as the same shell were used indiscriminately for the 68-Pounder and 8-inch Guns.

2 68-Pounders were lent to the French—one of them burst, but from the state of vent it is apparent that it had been fired long, and that it was the result of over work and not the fault of the metal.

These guns are from the Low-moor Foundry, and of the date 1847 to 1855.

10-*inch Guns* 85 *cwt.*

There were ten 10-inch Guns of 85 cwt., in use during the siege—one burst—one became unserviceable from use, and one was destroyed by the enemy's fire.

The total number of rounds fired was 6,111. The greatest number in use at any one time was 7, which gives an average of over 900 rounds for those first placed in position.

These Guns have, with the exception of one of them, suffered very slightly. The Gun which became unserviceable was marked W. and Co., but had no date. The remainder were from Low-moor Foundry, and their date 1849.

8-*inch Guns.*

76 8-inch Guns were in use during the siege—none of these Guns burst—25 were destroyed by the enemy—36 have been condemned since the termination of the siege.

The total number of rounds of 8-inch ammunition fired was 64,280, out of this 20,000 common shells were used indiscriminately by the 8-inch and 68-Pounder Guns of 95 cwt., but as there were never more than 46 8-inch Guns in

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use at any one time, it is evident that these Guns must have fired on an average considerably more than 1,100 rounds each. None of these Guns have been rebouched, and considering the heavy fire to which they have been subjected, their vents have suffered to a wonderfully small extent.

Those of 65 cwt. were marked B.F.O. on the trunnion, and were cast in the year 1813. Those of 53 cwt. were from W. & Co., and their date 1851 and 1854, and from Low-moor with date 1854. As a shell Gun the 8-inch of 53 cwt. was found very effective.

32-Pounder Guns.

Of these Guns 140 were in use of different natures; but never more than 50 of them at any one period—32 were destroyed by the enemy, and the number of rounds fired was 65,379—86 of these Guns were the 32-Pounder of 56 cwt.—one of these Guns burst from overwork—23 were destroyed by the enemy, 57 were condemned as unserviceable, and 6 remained serviceable at the end of the siege; many of these Guns had been rebouched, and some of them were condemned as unserviceable in July, but were replaced in the Trenches on the 3rd and 4th of September owing to the scarcity of any but 32-Pounder ammunition.

These Guns fired on an average over 1,500 rounds, and some of them from their position over 2,000 rounds. These Guns were from the Low-moor and W. & Co., Carron Foundries.

32-Pounder Guns, 50 cwt.

32 32-Pounders of 50 cwt. were in use—7 were destroyed by the enemy—25 remain serviceable, and their vents are good. The generality of these Guns fired over 600 rounds, and some of them considerably more. These Guns were cast at Low-moor in the years 1853 and 1854. The effect of these Guns was good, the velocity being the same as that of the heavy 32-Pounder of 56 cwt., while the ease with which they are got into position, and the facility with which

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they are worked, render them invaluable as a Siege Gun in the advanced trenches.

32-Pounder Guns, 42 cwt.

4 32-Pounders of 42 cwt. were in use and fired about 600 rounds a Gun. Two were disabled by the enemy's fire, the remainder are still serviceable and the vents good. These Guns were placed in position after the 7th June, they were cast by W. & Co., in the year 1846.

The effect of this Gun is exceedingly good.

Light 32-Pounders.

18 Light 32-Pounders of the old pattern, and of various weights, were in use at the commencement of the siege, but were all unserviceable before the April bombardment.

32-Pounder Guns (lent to the French.)

21 32-Pounders of 56 cwt. were lent to the French, some from the Carron Foundry bearing date 1806, and the rest from W. & Co., but with no dates. There is no return of the ammunition expended by these Guns, but from the appearance of their vents they must have been subjected to a severe and heavy fire.

One of these Guns burst, the remainder are all unserviceable, the vents being enlarged to a diameter varying from 1 to 2 inches.

24-Pounder Guns.

57 24-Pounders of 50 cwt. were in use during the siege—of these, 2 burst, 27 became unserviceable, and 25 were destroyed by the enemy. Some of these Guns have been in use since the April bombardment. 28,524 rounds of 24-Pounder ammunition were fired, and 30 is the largest number of these Guns ever in use at the same time, which shows they must have fired on an average 950 rounds.

Lancaster Guns.

8 Lancaster Guns were in use—of these 3 burst—these were all the light Lancaster—one was condemned as unser-

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viceable at the end of the siege—this Gun was a heavy Lancaster, of 95 cwt., it had been struck in the muzzle by a shell from the enemy, and was split during the April bombardment, but a foot having been cut off the muzzle, it was continued in use till the end of the siege.

Two heavy and two light are still serviceable.

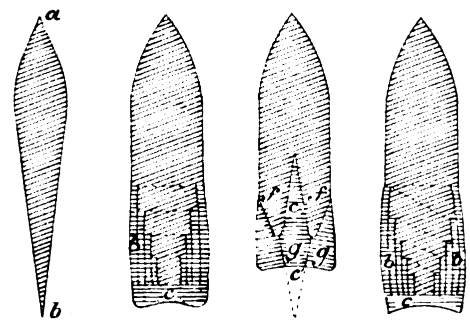
1,542 rounds of Lancaster ammunition were expended—they also fired a portion of the common 68-Pounder ammunition.

On Rifle Bullets.

To the Editor of the Mechanics' Magazine,

Sir,—I should consider a body of the shape represented by Fig. 1 as the most suitable for a projectile; for there would take place during its flight hardly any condensation (resistance) of air at its point, nor at *a*, any rarefaction of air behind (at *b*). The swiftest fishes and birds are propelled by

Fig. 1. Fig. 2. Fig. 3. Fig. 4.



a force from within them, and the organs and limbs by which they propel themselves would greatly tend to retard the speed of their flight, if they were projectiles; that is, if they were propelled by a force that is not within them—a *communicated*

force. In order therefore to find out the most suitable shape for a projectile, we should divest those birds and fishes of their organs of motion; and then we find, that they bear a great resemblance to the shape represented by fig. 1,

The greater the specific weight of a substance, the better is that substance suited for a projectile, because it takes up most of, and retains best, the communicated force.

If the propelling force is communicated to the bullet from *behind* (which at the present time is the case with all projectiles; but I fancy, that a *different* mode of communicating that force in *addition* to that at present in use, might be employed with advantage, respecting which I shall give some hints in another communication), then either the *bulk* or the *weight* of the projectile should decrease in the same proportion as, but in a direction *opposite* to, that in which the density of the propelling force decreases; otherwise the projectile would *turn* in its flight, and assume a reversed position. The projectile ought to have a proper "balance of flight."

The rifle bullets, whose sections are represented by figs. 2 and 3, appear to fulfil the required condition best, as they bear most resemblance to the theoretical shape represented by fig. 1. I do not consider those bullets, by which it is intended to stop all windage by the lead of the bullet expanding at the discharge, and filling the grooves, as the best and most advantageous, because by the cavity behind in the bullet being caused to expand, the original shape of the bullet would be more or less destroyed, the "balance of flight" of the bullet thereby be more or less disturbed, and thus the force, speed, and correctness of its flight be more or less affected. The bullet, fig. 2, however, would insure a proper balance of flight, and by means of the wadding (*leather*, &c., &c., *rings*, *b*, and *discs*, *c*,) all windage would be closed up most effectually at the discharge without the shape of the bullet being in the least affected or changed. Bullet, fig. 3, is on a similar principle; the wadding, *g*, (consisting of leather, cork, &c.

would, in expanding at the discharge, close up all windage; the cavity behind, *c*, tends to establish a proper balance of flight, and has, in this respect, the same effect, as if a tail, of the shape indicated by the dotted lines *c′* were attached to the bullet. The slanting sides, *f*, tend partly to facilitate *expansion of the wadding*, and chiefly to effect an *easier access of the air*, so as to counteract as much as possible the retarding influence of the rarefaction of air, which naturally would be caused behind the bullet during its rapid flight; and the pressure of the wadding against those slanting sides would counteract the pressure of the wadding in the cavity, *e*, and thus tend to preserve the proper shape of the bullet. The greater accuracy and correctness of the flight of projectiles, that have been shot out of *rifled* barrels, arises from the rapid rotary motion which has been communicated to the projectile by the shape of the barrel, which rapid rotary motion tends to counteract and neutralize the effect of any slight inaccuracies or inequalities in the barrel or bullet, that otherwise would affect the correctness of the flight. The force which is to produce that rotary motion must be a very superior one, so as to overcome and neutralize the above mentioned influence of such inequalities and inaccuracies, which, though they may be very slight indeed, would considerably affect the flight of the projectile, in proportion to the amount of force that has been communicated at the discharge. Experienced riflemen will have noticed with rifles or muskets, the fire-line of which deviated somewhat from the line of sight, that such deviation became the more considerable the larger the charge of powder they employed in loading the gun. Hence it is evident, that the whole amount of that rotary motion, if it shall at all reach its purpose, must be communicated to the projectile simultaneously with the propelling force itself, and must be effected either by the propelling force acting directly upon the bullet in such a manner as to cause it to rotate; for which purpose the bullet must have a peculiar appropriate shape, the same

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as (a spiral) or one similar to that represented by fig. 4; or by an appropriately modified resistance of the barrel, the shape of the barrel being such as to compel the bullet to assume a rotary motion; or by an *active agent* of sufficient strength being contained within the bullet. The rotary motion, which might be communicated to projectiles by the resistance of the air, I consider to be altogether inadequate; and, whatever peculiarity in the shape of the projectile would tend to divert the force of that resistance of the air in a higher degree towards causing the projectile to rotate, would at the same time tend to *lessen* in the same proportion the capabilities of the projectile for a rapid and well balanced flight. With a smooth barrel, that did not contain even the very slightest inaccuracy, with a bullet of the same proportion, and with a perfectly accurate charge, there might be reached even a much greater accuracy in the flight of the bullet than could be reached with the very best rifle. The construction of a barrel of such perfection is not an impossibility, although there would certainly be required several improvements in the tools and instruments employed for such purposes*.

I am, Sir, yours &c.

(Signed) G. J. GUNTHER.

London, Hotel Hamburgh,
John Street, Minories, March 1857.

An Experiment with Gun Cotton.

To the Editor of the Mechanics' Magazine.

Sir,—Wishing to ascertain the explosive power of gun cotton, I charged one of my leaden percussion rifle shells with as much gun cotton, as, when moderately pressed, equals in bulk the portion of the wooden plug that projects beyond the cylindrical chamber of the shell. The arrangement is shewn

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Mechanics' Magazine 4th April 1857.

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in section in fig. 1. I then placed the shell so plugged on an

Fig. 1.

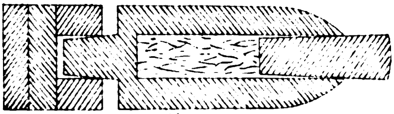

Fig. 2.

iron plate with a fire under it; when the shell was sufficiently heated it exploded, and the engraving, fig. 2, shews its appearance then. An earthen flower-pot was placed over it, to prevent its escape. The pot was blown to pieces. Fig. 1, represents the shell, with its tapering shank, to fix the expanding sabòt on, which is made of three circular pieces of sole-leather, glued together. It is thus that I fire elongated *iron* shot and percussion rifle shells from rifles without injury to the grooves of the rifle.*

I am, Sir, yours &c.

(Signed) J. Norton.

The American Breech-Loading Guns.†—Mr. Eastman's six breech-loading cannon, recently imported from America, were yesterday tried on the Arsenal Wharf, Woolwich, under the supervision of Lieutenant-Colonel Wilmot, Superintendent of Government gun factories at Woolwich, and having been twice fired with a double charge

* Mechanics' Magazine 4th April 1857.

† Artillery Records page 645, head "Miscellaneous."

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of blank cartridge—namely, 20lbs. of powder—they were examined, and found to have stood the test satisfactorily. From their enormous weight—17 tons—they did not evince the slightest recoil.*

The Armament of the "Merrimac."†

FROM A CORRESPONDENT.

The determination of the armament most suitable to Ships-of-war is a point which has lately attracted a good deal of attention, especially since the visit of the U. S. frigate, *Merrimac* to this country; and notwithstanding that copious information has already been given to the public in your pages, I think the following further "Notes" may possess interest.

To arm Ships-of-war with heavy shell guns alone is decidedly improper, particularly if such ships do not possess great steam power and move with great speed. Heavy shell guns should be the exception, and not the rule. In the English service, this appears to be understood and acted upon. A frigate fitted with thirty-two 68-pounders on her gun-deck, and sixteen 8-inch shell guns on her upper deck, with a heavy shell gun (to carry an elongated shot) forward and another aft, would have a much more effective armament for all purposes than the *Merrimac*. For close quarters, a shell of an oblong form is already adopted in our own service. A ship armed with 68-pounder solid shot would command the *Merrimac* in respect of range; so that in fact it is only *at a certain distance* that a ship armed with 9-inch shell guns only, could be said to be even on an equality with another (of equal size) armed as I have suggested above; and if the latter had a superior speed as well, the former would stand a poor chance, either at long bowls or close quarters. Another point is, that the *Merrimac's* guns could not be worked with so much celerity as the 68-pounders.

* Mechanics' Magazine, 15th August 1857.

† See Artillery Records," Miscellaneous," pages 441 to 447,

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There is another fact or two which it may be worth while to mention. The decks of our Men-of-war have blocks of hard wood let in under the gun carriages to receive the friction; these, which are very useful, the *Merrimac* is without. Again, in consequence of the thinness of Dahlgren's guns in the chase, a single shot striking them in action would send them to shivers. Further, the elevating screws to the guns have been tried in our service, and found not to answer, the female screw always going after a time; the screw itself is apt to get bent. It is a mistake to suppose that the substitution of bristles for sheepskins in the rammers is an improvement; on the contrary, the sheepskin serves much better than the bristles for one of the most important uses of the rammer, that of extinguishing the fire or sparks left in the gun after the discharge. Our own frigate *Shannon* steams at the rate of 12 knots an hour, and the *Merrimac* at about half that!

I may inform the "Naval Officer," whose interesting "notes" appeared *Mechanics' Magazine*, No. 1735,* that we have frigates now in course of construction much larger and much more heavily armed than the *Shannon*. We have also a line of battle ship or two of a very pleasing character in course of preparation.†

Timber-Bending Machinery.

It is unnecessary for us to inform our readers that the bending of timber is an operation which has hitherto been performed as rarely as possible, and always with very considerable trouble and expense. Every ship-builder knows perfectly well that the expenditure of time, labour, and material involved in bending a thick plank round a bluff bow, or round a quarter is enormous, and knows further that the

* Mechanics' Magazine, 22nd August 1856. Artillery Records, "Miscellaneous," page 445.

† Mechanics' Magazine, 22nd November 1856.

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impracticability of bending very thick timber at all, leads to fearful waste. At the same time, furniture makers and other workers in wood are well aware that a cheap and efficient method of giving circular, oval, and other curved forms to wood on a smaller scale, would be invaluable.

It is therefore with pleasure we are enabled to state that Mr. T. Blanchard, of Boston, America, has invented, and that a highly respectable English Company has been formed to carry out a new and excellent mode of bending timber of all kinds and dimensions, and into any required forms, within reasonable limits. Plate 43 represents the improved machinery, the action of which will be understood sufficiently for all ordinary purposes, without any more detailed description than the illustration contains. We have seen timbers of large dimensions bent (after having been suitably steamed), with the greatest facility, at the works of Messrs. Collinge and Co., patent hinge manufacturers, Westminster-road, Lambeth. The characteristic feature of the apparatus is that it subjects the wood during the bending process to pressure on all sides, by which it is prevented from bursting, crippling, or altering its form in any other than the desired manner. The *set* imparted to it becomes quite permanent after a few hours, during which it is kept to its form by an enveloping band and a holding bolt. A subsequent examination of the bent timber, sawn into slices, was most satisfactory.

It is highly gratifying to observe that the machinery for the working of which the new company has been formed, has received the unqualified approval of many persons whose opinions are not lightly pronounced. Mr. W. Fairbairn, says: "As President of the Jurors of Class 6, at the Paris Universal Exhibition, this invention came under my own immediate inspection and that of the gentlemen composing the jury of that class; and from the specimens there exhibited, and the experiments made in a working model, I am of opinion that this invention is destined to effect an entire

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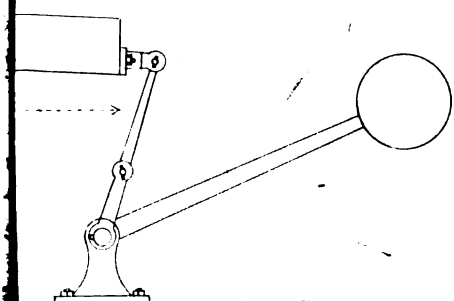
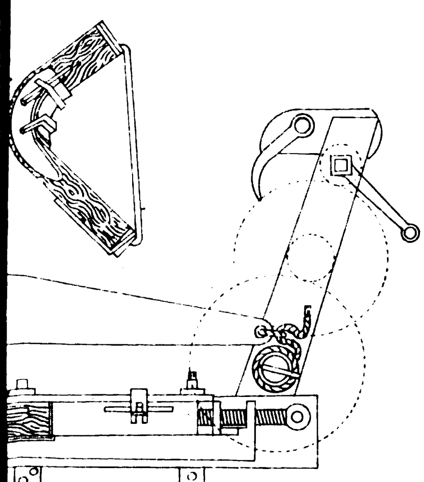
Plate 43.

inches square.





Elevation of Machine
the bending has taken place.
square.

W.E.

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revolution in the formation of timber requiring curvature of form." Mr. G. Rennie bears similar testimony. Mr. T. White, of Portsmouth, in speaking of the bending process, says: "the effect is *perfect*; the grain of the wood is not disturbed in the least, and in shipbuilding will be invaluable." Mr. J. Jarvis, United States' Government Inspector of Timber, writes of the invention in the warmest possible terms. He says: "The Navy and Merchant Marine will be so much benefitted by the use of this invention that we no longer miss the loss of our forests of white oak, for we can now bend young trees, not waiting their growth, into curves, which, when obtained so much across the grain, diminish the strength, at least seventy-five per cent. Our cabinet-makers will be able to get all the curved pieces without compressing the piece cross-grained, as hitherto done. I have been an inspector and measurer of timber in the navy yard for upwards of forty years, but no invention so important as the one under consideration has ever come to my knowledge in reference to the improvements in ship building." An English architect, Mr. Charles Mayhew, writes: "I have carefully examined the various specimens of timber bent by your machine, and have much pleasure in stating that I consider it one of the most useful and ingenious inventions I have ever seen, and must 'go a-head' of all other methods at present introduced in this country, owing to its extreme simplicity—its applicability to any curvature—and its capability of bending into a permanently set form any wood up to 16 inches square, however hard, not only without injuring its fibres, but positively rendering the wood more rigid, and, at the same time, increasing its strength to such an extent that, in a structural point of view, I am of opinion that, in many cases, it will supersede the necessity of using iron."

It is satisfactory to observe that when a really good invention, like the one before us, is introduced to the public notice in this country, it is sure to receive its due praise, without

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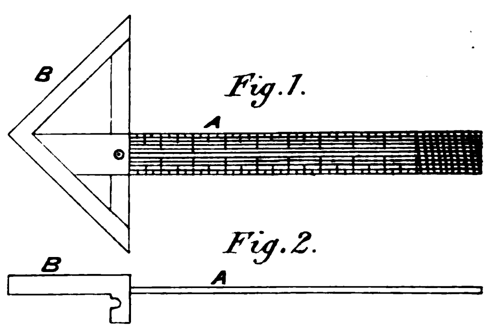
regard to its origin. Although an American invention, the English press, including the scientific portion of it, has given unstinted approbation to Mr. Blanchard's machinery. The *Builder* says: "The difficulty which at present exists in procuring timbers for ship-building of a natural growth suited to the forms required for knees, futtocks, &c., will be overcome by this invention; and, for purposes of furniture, &c., the saving of material (often of a very costly nature) must, we should think, insure its adoption by the trade."

It should be remarked, that the results of a series of experiments made at the Novelty Works, New York, under the inspection of Mr. Delano, Naval constructor of the Government Dockyard, Brooklyn, to test the relative strength of natural and machine-bent knees for ships, proved, according to the *Scientific American*, decidedly in favour of the machine-bent knees.*

Lancaster's United Service Square.

Mr. Charles Lancaster, the well-known gun-maker, of New Bond-street, has recently registered an "United Service Square," which is an exceedingly useful instrument. It is represented in plan and side view in figs. 1 and 2



respectively. Its construction will be understood from an

* Mechanics Magazine 17th January 1857

inspection of these figs. It may be formed of any suitable material and used as a drawing square; for finding the centres of circles; for setting out mitre joints internally and externally; for proving angles and squares; as a rule; and, generally, as an architect's, engineer's, or a mechanic's instrument.*

A proposed new method of constructing cannon, by T. A. Blakely, Captain H. P. Royal Artillery, M. R. I. A. &c. &c. &c.

CHAPTER I.

A strong 10-inch gun is much needed for the navy. Hundreds of thousands of pounds have, within the last few years, been spent in the vain attempt to cast at Woolwich a better metal than the experience of generations has enabled the Walkers of Gospel Oak or the Lowmoor Company to produce. This expenditure has been incurred because the weakness of large pieces of ordnance was wrongly attributed to the metal of which these were made; whereas it is easy to prove that the same proportional thickness of the same metal which will make an excellent 32-pounder will make a very bad larger gun.

In a 32-pounder the shot moves from its position just fast enough to enable the gas of the gunpowder to expand as it burns, so as never to press more than about five tons per inch, the combustion being complete when the shot has moved about 24 inches. At this period a gas, which if confined in a length of the bore but eight inches long, would give a pressure of 3,000 atmospheres or 20 tons per inch, having four times so much room, can only press 750 atmospheres or five tons per inch. In an 8 or 10-inch gun the shot moves more slowly from rest, while the powder burns more rapidly in proportion, so that for an instant the pressure would exceed five tons per inch. In much larger cannon the shot would move so leisurely that the pressure might reach 18 or 19 tons per inch.

* Mechanics' Magazine, 9th August 1856.

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To enable us, therefore, to obtain a really safe solid-shot gun, of even 10-inch bore, we must either use a material much stronger than cast-iron, or adopt some mode of making a given thickness of cast iron do more work: the latter is the method I would suggest, as I will presently explain. To obtain much greater strength by casting the gun heavier is impossible, because in cast guns (whether of iron, brass, or other metal) the outside helps but very little in restraining the explosive force of the powder tending to burst the gun, the strain not being communicated to it by the intervening metal. The consequence is, that, in large guns *the inside is split, while the outside is scarcely strained.* This split rapidly increases, and the gun ultimately bursts.

This will be more easily understood by considering the case of a much more elastic tube; for instance, an India-rubber cylinder 10 inches in internal diameter and 10 inches thick, therefore 30 inches in external diameter. (Fig. 1, Plate 44.)

Such a cylinder might be strained by pressure from within till the inside stretched to double its original circumference. The diameter would, of course, also be doubled, and would be 20 inches instead of 10.

Now it is evident that the outside circumference and diameter cannot be doubled at the same time, or else the latter must become twice 30 or 60 inches, which would give a thickness of 20 inches; quadrupling the mass of material, which is impossible.

A moment's reflection shows that the thickness must diminish as the circumference is increased by pressure from within; for, if the thickness remain 10 inches, when the internal diameter has become 20, the external diameter must be 20 plus twice 10, or 40 inches. (Fig. 2, Plate 44.)

This could not be, unless we imagine what seems impossible, viz.—that the bulk of the material is considerably enlarged; as each inch in length of the cylinder would now con-

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Miscellaneous.

Fig. 1.

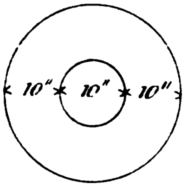


Fig. 2.

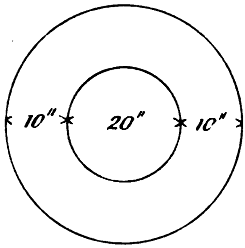


Fig. 3.

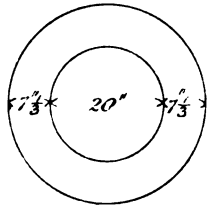


Fig. 4.

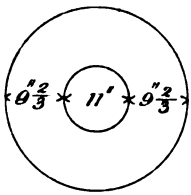


Fig. 5.

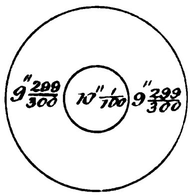


Fig. 8.

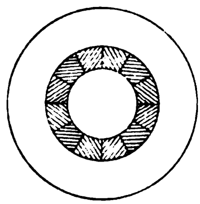


Fig. 6.

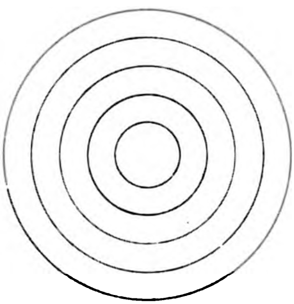


Fig. 7.

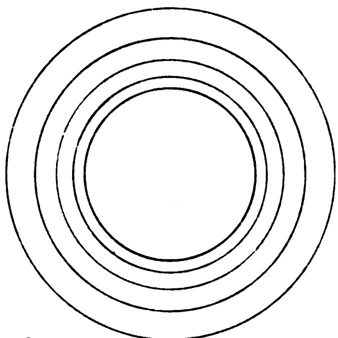
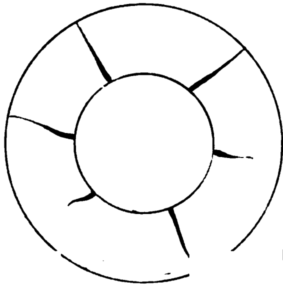


Fig. 9.



Madras Arty: Dept.

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tain 1,200 cylindrical inches (the difference between the squares of 40 and 20, the external and internal diameters,) whereas originally it only contained 800 inches, the difference between the squares of 30 and 10.

Yet, *even if the thickness could remain the same, notwithstanding the increase of circumference, the outside layer could only be strained one-third as much as the inside one, because three times as long.* The same elongation, which would cause a strain of one ounce or one pound in the longer circumference, would cause a strain of three ounces or three pounds in the shorter one; and the elongation which would but moderately strain the one would break the other.

This reasoning is equally applicable to the minute extension of iron; the increase of $\frac{1}{10}$ of an inch in the outer circumference of a 10-inch gun being possible without fracturing that part, being an elongation of but 1 in 940; whereas the same extension must crack the inside, as no iron could stand an elongation of $\frac{1}{10}$ in $31\frac{1}{2}$, or 1 in 314.

Even on this showing, then, the outside of a thick tube cannot do its share of work; a closer examination, however, must convince us that this is an over estimate of it, for *the thickness of material must diminish as the circumference is increased.*

When the inner diameter of the 10-inch cylinder becomes 20 inches, the thickness must diminish from 10 to 7·32 inches, the cross-section of the cylinder remaining the same. (Fig, 3, Plate 44.)

This cross-section was originally 800 circular inches, 800 being the difference between the squares of 30 inches, the outer diameter, and 10 inches, the inner, or 900 minus 100.

When stretched, the area of the cross-section must continue to be 800 round inches.

Now a thickness of 7·32 inches gives us an external diameter of twice 7·32 or 14·64 added to 20, the internal diameter, in all 34·64 inches, the square of which is 1,200. Sub-

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tracting 400, the square of 20, leaves 800 round inches as before.

In this case the outside of the cylinder is stretched but 4·64 in 30, about one in seven, when the inside is stretched to double its original size.

If the inner diameter be only stretched to 11 inches, the thickness must be diminished from 10 to 9·674 inches, the outer diameter becoming 30·348 inches, (Fig. 4, Plate 44) the cross-section remaining 800 round inches as before, the difference between the squares 30·348 and 11. Here the outer layer is elongated ·348 in 30, or 1 in 86; whereas the inner is extended 1 in 10, showing a strain or an exertion of power $8\frac{1}{2}$ times greater.

In the minute extension of metals the disproportion is still more striking. Thus in cast iron the 10-inch inner diameter may become $10\frac{1}{100}$, which would extend the outer diameter only from 30 to $30\frac{1}{300}$, the cross-section remaining 800 inches, and the thickness diminishing from 10 inches to $9\frac{299}{300}$. (Fig. 5, Plate 44.)

Here the outside would only be stretched $\frac{1}{300}$ in 30, or 1 in 9,000; the inside being stretched $\frac{1}{100}$ in 10, or 1 in 1,000, exerting, therefore, nine times as much power as the outside.

It is evident that a slight increase of pressure from within would break the inside, while the outside could help but little in restraining the disruptive force.

If we make equidistant circular marks on the end of an India-rubber cylinder (Fig. 6 Plate 44,) and stretch it, we can see plainly how much more the inside is strained than the outside, or even the intermediate parts. The spaces between the marks will become thinner, each space becoming less thin than that inside of it, but the inner space much thinner than the others, (see fig. 7 Plate 44,) showing that when the inside is strained almost to breaking, the intermediate parts are doing much less work, and those far removed almost none.

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In the first volume of the "Transactions" of the Institute of Civil Engineers, p. 133, there is a paper by Professor Peter Barlow, F. R. S., on the Strength of Cylinders. The law* he deduces is that "*in cylinders of metal the power exerted by different parts varies inversely as the squares of the distances of the parts from the axis.*" Thus in a 10-inch gun, when the inside, which is 5 inches from the axis, is fully strained, the metal 2 inches from the inside or 7 inches from

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* The following are the Professor's own words : "It would appear at first, that having found the strain at D and C, it would only be necessary to ascertain the thickness of metal necessary to resist this strain when applied directly to its length ; this, however, is by no means the case, for if we imagine, as we must do, that the iron, in consequence of the internal pressure, suffers a certain degree of extension, we shall find that the external circumference participates much less in this extension than the interior, and as the resistance is proportional to the extension divided by the length, according to the law *ut tensio sic vis*, it follows, that the external circumference, and every successive circular lamina, from the interior to the exterior surface, offers a less and less resistance to the interior strain : the law of which decrease of resistance it is our present object to investigate.

"In the first place, it is obvious that whatever extension the cylinder or ring may undergo, there will be still in it the same quantity of metal, or, which is the same, the area of the circular ring, formed by a section through it, will remain the same, which area is proportional to the difference of the squares of the two diameters.

"Let D be the interior diameter before the pressure is exerted, and $D+d$ its diameter when extended by the pressure. Let also D' be the external diameter before, and $D'+d'$ the diameter after the pressure is exerted ; then from what is stated above it follows, that we shall have

$$D'^2-D^2=(D'+d')^2-(D+d)^2$$

$$\text{or, } 2D'd'+d'^2=Dd+d^2$$

$$\text{or, } 2D'+d' : 2D+d :: d : d'$$

or since d' and d are very small in comparison with D' and D, this analogy becomes $D' : D :: d : d'$. That is, the extension of the exterior surface is to that of the interior as the interior diameter to the exterior.

But the resistance is as the extension divided by the length, therefore the resistance of the exterior surface is to that of the interior as $\frac{D}{D} : \frac{D'}{D}$ or as $D^2 : D'^2$. That is, the resistance offered by each successive lamina, is inversely as the square of the diameter, or inversely as the square of its distance from the centre ; by means of which law the actual resistance due to any thickness is readily ascertained.

Let r be the interior radius of any cylinder, p the pressure per square inch on the fluid, t the whole thickness of the metal, and x any variable distance from the interior surface. Let also $rp=s$ represent the strain exerted at the interior sur-

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the axis can only exert a force $\frac{25}{49}$ or little more than half as much; 3 inches further, 10 inches from the axis, the force exerted diminishes to $\frac{25}{100}$, or but a quarter of that exerted by the inside; and if the gun be 12 inches thick, *the outside*, which is 17 inches from the axis, *can exert but* $\frac{25}{289}$, *or about* $\frac{1}{12}$ *as much power as the inside.* Of course, casting the gun still thicker would add but very little to its strength; we cannot, therefore, be astonished that it has been found in practice that cylinders for hydraulic presses, with a thickness equal to about $\frac{1}{2}$ the diameter of the piston, are very nearly as strong as if ten times as thick.

In 1855, Dr. Hart of Trinity College, Dublin, investigated the problem. His calculations (see note W p. 259, of Mr.

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face, according to the principles explained in the preceding part of this paper. Then by the law last illustrated we shall have,

$(r+x)^2 : r^2 :: s : \dfrac{r^2 s}{(r+x)^2}$ for the strain at the distance x from the interior surface;

and consequently $\int \dfrac{r^2 s dx}{(r+x)^2}$ + Cor.=the sum of all the strains, or the sum of all the resistance. This becomes, when $x=t$, $R=r^2 s\left(\dfrac{1}{r}-\dfrac{1}{r+t}\right)=s\dfrac{rt}{r+t}$. That is, the sum of all the variable resistances due to the whole thickness t, is equal to the resistance that would be due to the thickness $\dfrac{rt}{r+t}$ acting uniformly with a resistance s, or rp.

APPLICATION OF THIS RULE FOR COMPUTING THE PROPER THICKNESS OF METAL IN A CYLINDRIC HYDRAULIC PRESS OF GIVEN POWER AND DIMENSIONS.

Let r be the radius of the proposed cylinder, p the pressure per square inch on the fluid, and x the required thickness: let also c represent the cohesive strength of a square inch rod of the metal.

Then from what has preceded it appears, that the whole strain due to the interior pressure will be expressed by pr, and that the greatest resistance to which the cylinder can be safely opposed is $c \times \dfrac{rx}{r+x}$: hence when the strain and resistance are in equilibrio, we shall have $rp=\dfrac{rx}{r+x}\times c$ . . . . . . (1)

$$pr+px=cx$$

whence $x=\dfrac{pr}{c-p}$ (the thickness) sought.

R. Mallet's work on the Construction of Artillery) give greater strength to the inner parts, but still less to the outer, than those of Professor Barlow. Both these gentlemen,* as well as General Morin and Dr. Robinson, the astronomer, who have also studied the question, agree that *no possible thickness can enable a cylinder to bear a pressure from within greater on each square inch than the tensile strength of a square inch bar of the material;* that is to say, if the tensile strength of cast iron be 6 tons per inch, a cylinder of that metal, however thick, cannot bear a pressure from within of 6 tons per inch. This has been found practically true with hydraulic presses, and, indeed, with guns also, a 32-pounder being the largest which can with safety be fired with a full charge of powder.

As we much want a stronger 68-pounder and 10-inch gun, we must therefore seek some other method of construction than casting them of iron. Steel guns have not yet succeeded on a large scale, and if they did it would be a pity to use so valuable a material so unscientifically that one part shall be strained to breaking while another is idle. The same may be said of wrought iron.

The remedy I would venture to suggest for the unequal strain on different parts of the thickness of a gun, is extremely

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*Dr. Hart's formula for the pressure a cylinder can bear is

$$p = t\frac{R^2 - r^2}{R^2 + r^2} \qquad (2)$$

where p is the pressure on each square inch of interior surface, t the tensile force of a square inch bar of the material, R the radius of the outer surface of the cylinder, and r that of the inner surface or bore.

Using this notation Professor Barlow's formula (1) is

$$p = t\frac{R - r}{R} \qquad (3)$$

These equations become identical when R is indefinitely large compared with r

then $p = t$

which means that an *infinite thickness* of metal is requisite to bear a pressure on each inch of the bore equal to the tensile force of a square inch bar of the metal. Yet a thickness equal to the radius of the bore would suffice, if each particle were equally strained.

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simple. SEVERAL PARTS SHOULD BE MADE TO TAKE A MODERATE SHARE OF THE STRAIN, instead of the inside having too much and the rest of the gun too little, as in a cast gun, or the inside none and the middle too much, as in the old mode of manufacture with hoops and staves of iron.

One glance at fig. 8, (Plate 44) which represents a section of a gun of the latter construction, will suffice to convince us of the futility of the attempt lately made to reintroduce it. It has nearly all the defects of a cast gun, (particularly that of the unequal straining of its parts), besides others peculiar to itself, the penetration of the gas between the staves, for instance.

A more equal distribution of strain can only, I think, be secured by building guns of concentric tubes, each slightly too small to be placed over the one below it without force. The difference of size necessary is easily calculated with sufficient exactness for practical purposes. The greater the number of layers the greater the strength, as by a minute subdivision, all parts, doing but one-half their share of work, or less, can be replaced by metal capable of exerting nearly its whole force with so small an additional extension as not to render an undue extension of any other part necessary.

A very simple way of making a great number of parts each exert an equal amount of power, is to wind wire round an inner tube with a tension increasing with each layer.

Very shortly after I took out my patent for this mode of constructing cannon, Mr. James Longridge, an eminent Civil Engineer, took out one for manufacturing Hydraulic Presses in the same way. He made several experimental cylinders; and some with sides but one-third as thick in proportion as those of a gun were filled with gunpowder, closed hermetically with the exception of a small vent, and without injury bore the shock of the explosion of the contained powder.

The pressure cannot have been less than 17 tons per inch, an amount which certainly the tubes could not have borne for a much longer period. These cylinders had flanges to keep the

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wire on. Some of these gave way as shown in Fig. 9, (Plate 44) the cracks being much more open at the inside and some not extending to the outside, thus proving how comparatively little the latter was strained.

Mr. Longridge has lately made a 6-inch cylinder for a Bramah press, which, with sides of $\frac{3}{4}$ of an inch of cast iron, covered with $\frac{1}{2}$ inch of wire (10 coils of $\frac{1}{16}$ inch wire), has borne a pressure of five tons to the inch—a much greater proof than ordinary cylinders of treble the thickness are subjected to.

Although a greater number of layers gives greater strength, still much benefit arises from the division of the metal even into two. I made a 9-pounder gun of two layers—the inner one 4 inches in bore, and $10\frac{1}{2}$ inches in outer diameter, cylindrical from the breech to the trunnions. Over this part I put another layer, about the $\frac{1}{100}$ of an inch *less than* $10\frac{1}{2}$ inches in inner diameter, and tapering outside from the breech end. The outer tube I made of wrought iron and, for convenience, of four pieces. When finished, the gun had exactly the appearance of an ordinary one, and was about the same weight as the service cast-iron gun, against one of which, as well as a brass service-gun and one made by Mr. Dundas of Dundas, (of wrought iron staves hooped together), mine was tried at Shoeburyness, by order of the Ordnance Select Committee, in 1855 and 1856.

The four guns were fired as follows:—

2	rounds with	8	lbs. of powder and	2	shot.
86	,,	3	,,	1	,,
16	,,	4	,,	1	,,
5	,,	5	,,	1	,,
5	,,	5	,,	2	,,

So far all four remained serviceable. The charge was increased to 6 lbs. of powder and 2 shot, with which Mr. Dundas's gun *burst at the third round*; *the service cast-iron gun burst at the* 110*th round;* the service brass gun became

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unserviceable after 174 rounds; but *my gun was so sound after* 318 *rounds*, that the charge was increased by one shot at a time, till the gun was *loaded to the* MUZZLE, in which state it was fired 158 times before it burst. This astonishing endurance must not be attributed to the mere substitution of wrought for cast iron in the outer inch and a quarter. The mere change of material added but one-seventh as much strength as the change in the size of the outer layer, for without this adjustment of size the wrought iron could not have exerted its power, as when the inner metal was fully strained, and the diameter of the bore increased from 4 to 4 $\frac{1}{150}$ inches, the diameter of the outside of the inner layer could be extended only from $10\frac{1}{2}$ to $10\frac{1}{2}$ plus $\frac{1}{666}$ inch, one in 7,000. With such a slight enlargement, the outer layer could not be pressed against enough to enable it to exert its full force, good wrought iron extending one in 7,000 with a tension of one ton and a half per inch. By making the outer layer $\frac{1}{100}$ inch less in diameter originally, I secure, that when the outside of the inner tube stretches $\frac{1}{700}$ of an inch, the outer tube shall be extended $\frac{1}{100}$ added to $\frac{1}{700}$, or $\frac{1}{87}$ of an inch, being one in nine hundred, the elongation due to an exertion of power equal to $10\frac{1}{2}$ tons, seven times greater than the mere substitution of wrought iron could give.*

* It may, perhaps, make the above more evident, if we consider the case of India-rubber. We found that a tube of this material, 10 inches in bore and 10 inches thick (see fig. 1, Plate 44), when stretched till the diameter of the inside is doubled, diminishes in thickness fron 10 inches to $7\frac{1}{4}$. (fig. 3, Plate 44.)

Now if we attempt materially to strengthen this tube, by merely fitting another accurately over it, we must fail, because so little of the strain will be communicated to the outside, the inner diameter of which can at most be stretched from 30 inches (its original size) to $34\frac{1}{2}$, the size of the outer diameter of the inner tube when stretched. Even this amount we should lessen, on occount of the pressure on the inner tube, which would make it slightly thinner and longer.

If, however, we put a tube whose inner diameter is only $17\frac{1}{4}$ inches over the inner one, (for which purpose the former must be temporarily stretched, as the outer diameter of the inner tube is 30 inches), then both tubes will be nearly equally strained when the inner diameter of the inner tube is doubled, as the inner diameter of the outer tube will also be doubled, becoming $34\frac{1}{2}$, having originally been but $17\frac{1}{4}$.

Any number of layers of tubes can be made, each to do a fair share of work, by regulating their original size, so that when the inner tube is extended to a certain amount, each shall be extended to the same amount. Should this amount be exceeded, however, the inside will again have an undue share of strain. On the other hand, a small strain will affect only the outer layer.

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Miscellaneous.

Fig. 12.

Section through C.D.

Fig. 10.

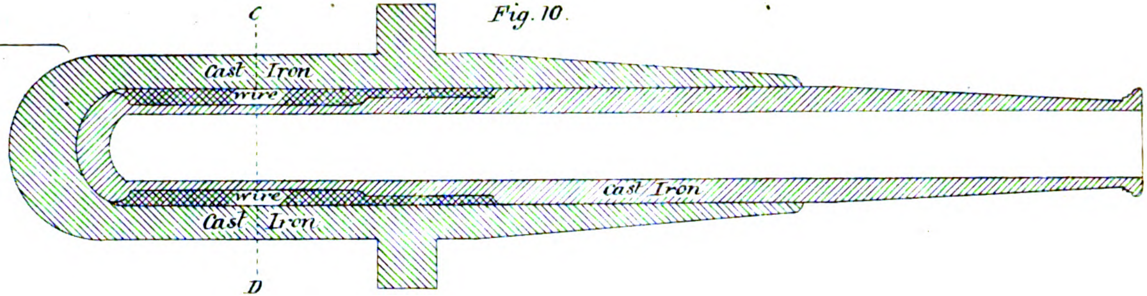
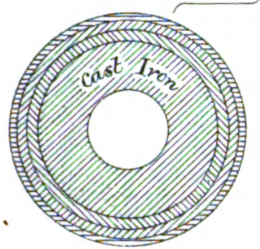
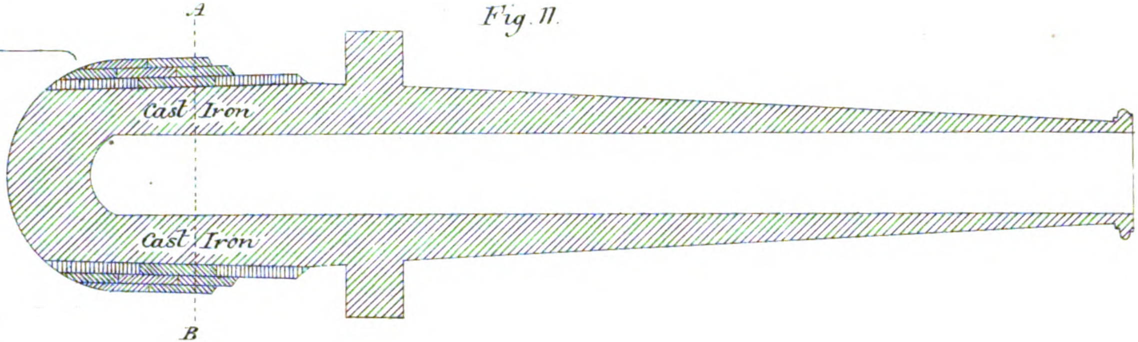


Fig. 13.



Section through A.B.

Fig. 11.



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N.S.

W. P. E.

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In a 68-pounder the strength of two layers will probably suffice, but for larger guns more of the metal must be made to take a fair share of work.

Care must be taken to have sufficient longitudinal strength. For this purpose some circumferential strength may well be sacrificed, by casting one part the length of the entire gun, and of adequate thickness.

For various reasons it seems better that this single large piece should be the inside, cast iron being admirably suited for the bore of a gun, whereas wrought iron generally has some defect in the welding, which would certainly be penetrated by the gas of the powder. In some cases, for instance in breech-loading guns, it may, however, be preferable to have the longitudinal strength outside. The latter construction has the advantage of giving greater circumferential strength; for (strange though it may seem) an ordinary cast gun, whether of iron or brass, would be strengthened at the breech by removing one-quarter of the thickness from the inside, and replacing the metal with even lead or pewter. The reason of this apparently paradoxical increase of strength is, that each remaining portion could do more work without any part giving way in the proportion of 3^2 to 2^2 or 9 to 4, when the inner part (which must yield first) is larger than as at present in the ratio of 3 to 2.* The gain of power by thus permitting the outside to exert more of its force is greater than the loss by removing the inner parts, which must have cracked before the outer could be moderately

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* Professor Barlow's expression (1) for the strength of cylinders (note page 693) $\frac{c\ r\ x}{r+x}$ gives us $c \times \frac{4 \times 8}{12} = c \times \frac{32}{12}$ as the strength of an 8-inch gun with sides 8 inches thick, and $c\,\frac{6 \times 6}{12} = c \times \frac{36}{12}$ as that when the bore is increased to 12 inches; the thickness being *diminished* from 8 to 6 inches, yet the strength increased. This is interesting, as it proves that hydraulic presses would be much stronger if cast thinner.

Dr. Hart's formulæ give the same result, and experiment has confirmed it.

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strained. A brass lining near the breech of a gun would evidently add much to its strength. This would also be a convenient way of strengthening mortars already cast.

With the exception of the single large piece for longitudinal strength the gun may, with advantage, be formed of a number of small tubes accurately put together. Mortars which are seldom subject to the fire of an enemy, cannot be more easily and strongly made than of wire, wound with the proper tension round an inner tube of brass, steel, or iron.

Mr. Longridge made a wire gun weighing but three cwt. from which he obtained ranges of 1,500 yards with 9 pound shot. The service brass 9-pounder weighs 13 cwt.

Figs. 10 and 12 (Plate 45) show a horizontal and a transverse section of a wire-strengthened gun. One made with these proportions could bear any strain gunpowder could directly cause. I can therefore see no reason why a solid shot weighing a ton should not be thrown eight miles from such a gun.

Figs. 11 and 13 (Plate 45) are a longitudinal and transverse section of a gun formed principally of cast-iron, and reinforced near the breech with three layers of tubes forced on. I should prefer wrought-iron for the latter. These guns may seem stronger than necessary near the breech, but it must be borne in mind, that it is only there that the largest guns are more strained than the smallest.

In various other obvious ways my object can be effected. This object is—SO TO CONSTRUCT GUNS THAT AT THE MOMENT OF FIRING THE GREATEST POSSIBLE PROPORTION OF THE THICKNESS OF METAL SHALL BE NEARLY EQUALLY STRAINED.

In consequence of the wonderful endurance of my 9-pounder (see page 697), the British Government is now trying experiments with an 8 and a 10-inch gun of the same construction. It is expected that an 87 cwt. 10-inch gun can be made capable of firing solid shot of about 130 pounds.

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For this purpose the metal should have been distributed differently, a greater thickness being given to the breech end: however, I anticipate a successful result even from the gun now at Woolwich on the pattern of the ordinary shell-gun.

As an experiment, a 10-inch gun is quite large enough, and for all combats between ships as at present built, I think 8 or 9-inch shells will be more effective than larger ones, *but for some FEW purposes monster howitzers would be most useful*—in the bombardment of a maritime fortress from the sea, for instance, or for the protection of the entrance to a river or harbour.

Although by doing so I must provoke ridicule, I feel it my duty to record my firm conviction that there is not the slightest difficulty in manufacturing cannon large enough and strong enough to throw shells of five tons, five miles. We *have made* cylinders which *have borne* the full shock of the explosion of gunpowder almost hermetically confined in them. A greater strain than this cannot be caused by firing a shell of any size, if gunpowder be used.

I have but a very faint hope that the truth of this will be acknowledged; but knowing it, my duty is plain. I must and do warn England that guns can be made capable of bombarding Portsmouth from such a distance that the vessels carrying them could scarcely be seen from the shore. Since the discovery of the method of making such guns, the chance of an enemy having the command of the Channel for a few hours even, has become a matter of some importance.

CHAPTER II.

A simple and cheap way of making cannon on the principle I advocate, is to cast a tube resembling a gun. but tapering slightly from the trunnions to the breech, the thickest part being at the trunnions (cast iron is an excellent material for this inner tube), and over it to force a tube of either cast or wrought iron accurately turned inside. This can be done

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with a hydraulic press, or by other suitable means. If this second tube be of wrought iron it will be advantageous to make it in several parts, to be fitted end to end, but NOT welded. These parts can be forced on the inner tube one after the other. Over the second tube a third can be forced, and for very large guns a fourth, and even fifth (see figs. 11 and 13 Plate 45). Great strength will be required, however, only at the breech. The amount of initial extension of the tubes can, by the above means, be accurately adjusted. I prefer wrought iron for all the tubes but the inner one: To this the Ordnance Select Committee objected in June 1855, "that cast and wrought iron have different expansive powers," therefore cannot be made to work together with safety. So fatal to my plans did that learned body think this objection, that it expressed its desire not to be troubled with any further experiments, thinking they must fail. (See their letter in Appendix A). However, when the sealing of my patent permitted me to explain my views more fully, I was permitted to send a 9-pounder gun for proof. This gun was fired against a cast-iron service-gun, and showed an immense superiority; standing (after many rounds with smaller charges), 318 rounds with 6 lbs. of powder and 2 shot without material injury, whereas 110 rounds with the same charge burst the cast-iron gun. See the Official Report, Appendix B). So little had this proof strained my gun, that it was afterwards loaded to the muzzle, and fired 158 times before it burst. Seeing this success, the Select Committee recommended the manufacture of an 8-inch gun on my plan, and both that and a 10-inch gun have been made at Woolwich Arsenal, and are now, I understand, under trial.

Finding my plans thus in a fair way of being adopted, and that I could not much hasten so desirable a consummation by any effort, I meant to let things take their course; but the Select Committee having reported (see Appendix B), that to me was due the credit of bringing to the notice of Govern-

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ment a valuable invention, I thought an acknowledgment of this from the Minister for War might facilitate my employment on the Staff of the Army. I therefore begged Lord Panmure to call upon the Select Committee for a report of their opinion of my invention, and if that were favourable, to forward my wishes by communicating it to His Royal Highness the Commander-in-chief. The following is the report of the Ordnance Select Committee:—

"January 15, 1858.

"The Committee begs leave to make the following statement relative to Captain Blakely's claim to being regarded the first who has called attention to an important principle in the construction of guns.

"There are many examples of compound guns of ancient date still in existence: indeed, this appears to have been the original system pursued in making ordnance. None is, however, known to the Committee precisely answering to the conditions described as a cast-iron cylinder or bore, having wrought iron rings upon it.

"In the 'Aide-memoire' of General Gassendi, as quoted by M. Thierry in 1834, it is stated that in 1813 a company at Lyons proposed to make wrought-iron cannon, and that they made an 8-pounder field piece, the construction of which is thus described:—On a tube formed as a cannon, successive bands of iron embracing the tube were soldered* on, one above the other, until a sufficient thickness, &c. &c."

* How can the Committee think that *soldering* bands of iron on a tube will distribute the strain equally? On receipt of their report I consulted Sir Charles Fox as to whether he saw any similarity between this plan and mine. His reply was, that merely soldering on bands would not give nearly so much additional strength as my plan of *forcing* on the outer tubes. This *force* (or its equivalent) Sir Charles considers *essential* (see his letter, C Appendix). I also consulted Mr. James Longridge, a Civil Engineer, well known for his mathematical attainments. He replied (see D Appendix), that there is a "*most essential difference* between soldering one tube on another, and contracting it on." The latter method has the same effect as using force, but is not under such perfect control.

Re-assured by the replies of these gentlemen, I inquired further into the doings of the Lyons Company, and found that *their mode of construction not only*

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" M. Thierry himself then proposes the trial of a cast-iron " cannon with an envelope of wrought iron adjusting it to " the resistence of the gun, and preserving it during explo- " sions from danger of bursting.

" About the year 1834, Colonel Frederix of Liege, pro- " posed the strengthening of an 18-inch mortar, similar to " that used at Antwerp, by adding wrought-iron rings.

" This was done, and the mortar was tried at Bruschaet. " It is now in the Musée d'Artillerie at Antwerp.

" In 1840, the proposition of Colonel Frederix to fire 28- " pounder guns of cast-iron, one having wrought-iron rings on " it from the breech to the trunnion, was carried out.* A

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did not equalise the strain, but absolutely paralyzed the outer portions more than the usual method. They formed the inner tube of bars of iron welded longitudinally, therefore incapable of stretching circumferentially more than *half as much* as if the so-called fibre were in the tranverse direction. The outer tubes they made with the fibre round them, therefore incapable of exerting their power without being stretched to an amount which must have not merely cracked the inner tube, but opened *large* fissures in it! The same plan was adopted by the Mersey Steel Company for the 13-inch gun, so patriotically presented by them to the country, except that they welded, not soldered, the parts together. As a triumph of mechanical power this piece of wrought iron stands unrivalled—as a gun it is subject to the above objections, *fissures having already appeared* in the inner tube.

(*Note by Captain Blakely.*)

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* The plans of M. Thierry and Colonel Frederix seem identical. They would have an advantage over cast-iron guns, because, as we have seen, the outside may extend about one-tenth as much as the inside. Now, if the outside be of cast-iron, it can only exert a force of half a ton per square inch when the inside is fully strained (5 tons per inch), but if it be of wrought-iron the same extension will accompany an exertion of power of nearly one ton per inch. This is an improvement certainly, but so slight as to be too dearly bought at the trouble and expense of a quantity of extra turning and other work. By *forcing* on the outer tube, originally smaller than the outside of the inner one by the requisite amount, we can without difficulty make the wrought-iron do six or seven times as much work as M. Thierry did. It is really surprising that the Select Committee should refer to inventions a quarter of a century old, as it is well known that the action of iron under strain was not investigated so long ago. In their own report, indeed, they *acknowledge that the theoretical considerations connected with this subject were first placed before them, in a tolerably complete form, by myself in* 1855; they further acknowledge that the same calculations were imported as a great novelty from America in 1856! These calculations, like those of Professor Barlow, refer to the evil, not the remedy for it, which I firmly believe I was the first to publish.

(*Note by Captain Blakely.*)

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" drawing of this, and a memorandum was kindly furnished " to the Superintendent, Royal Gun Factories, by Colonel " Frederix in 1855, and the former, with a translation of " the latter is appended to the Report.

" This gun was in the Great Exhibition of 1851, and is " still in existence.

" In 1845, Professor Treadwell of the United States " called attention to the comparative resisting powers of " wrought and cast iron. The pamphlet was translated into " French in Paris in 1848, and is in possession of the Com- " mittee. He proposes a gun built of several rings or muffs " of wrought-iron, joined end to end* by welding. Each " muff is composed of others placed concentrical and welded " one on the other—or he makes each of thin steel—or he " takes a bar of iron wound spirally round as a ribbon.

" The gun so made is at Vincennes.

" In 1851, Mr. Bodman† called attention (*sic*) of the " authorities in America to the theoretical considerations " connected with cast-iron in a state of various tension, and " on the theory then advanced, (similar to that now brought " forward by Captain Blakely), he was permitted to alter " the system of casting iron ordnance for experiment.

" This paper was not known in this country until 1856, " but the results were well known to the Committee on " Machinery, which visited the United States in 1854.

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* By these means as perfect a wrought-iron gun was obtained as could be made of a welded mass, but the strain was distributed exactly as in a cast gun. *The learned Professor has given up this plan and now advocates the same principle of construction as I do.* In 1856 he read a paper on the subject to the American Academy, of which he is Vice-President. *Surely a paper from such a person to such a body is strong proof of the novelty and value of the principle explained.*

† Mr. Bodman perceived the defect of ordinary cast guns being subject to undue strain in the inside, but the remedy he suggests is totally different from that I wish to see adopted.

(*Notes by Captain Blakely.*)

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"In 1852 Mr. Daniels proposed to the Committee to "place steel rings on old guns.*

"In 1854 Mr. Dundas filed a provisional specification for "forming a gun by shrinking wrought-iron hoops or cylin-"ders expanded by heat on to staves kept cool by artificial "means.†

"In 1855 Captain Blakely has a Provisional Specification "indicating a system of forming guns of an internal tube "or cylinder, having collars or rings *driven on*, the interior "being shrunk for the time by the application of cold.

"The strengthening of old guns is here proposed to be "done by "*driving on*" rings, or by the use of coils of "wire.

---

* This proposal seems similar to M. Thierry's; the object being to obtain strength by change of material, not adjustment of the size of parts.

† This differs in nothing but the method of putting the parts together, from the old system of making guns or rather *bombards* (see fig. 8; Plate 44). Such a gun is subject to at least all the objections I urged against the guns of the Lyons Company, being exactly on a par with one of those whose inside had cracked, thus allowing the gas to press on a large surface to the great danger of the gun.

The inferiority of this mode of construction to mine, or even to the ordinary method of casting, was proved at Shoeburyness by experiment. One of Mr Dundas' guns was fired against one of mine and a cast-iron gun. After about 120 rounds from each gun with smaller charges, Mr. Dundas' was fired with 6lbs. of powder and 2 shot *three times and burst*; the cast gun was fired 110 times with the same charge before bursting, and mine was fired 318 times, and even then, was so little injured that it was afterwards loaded to the muzzle, and fired 158 times in that state before it burst.

Captain Younghusband reports, that after the 26th round with 4lbs. of powder (114th in all) it was found that there was a slight opening between two of the longitudinal internal staves in Mr. Dundas's gun—13 rounds after this of course burst the gun. As the most candid of us are bad judges in our own cases, I wrote to Dr. Hart, to ask if he saw any similarity between Mr. Dundas's plan and mine. I give his very interesting reply at length in the Appendix (E). He says he planned a gun similar to mine, *to avoid the defects* of such a gun as Mr. Dundas's as well as those of a cast gun.

For extremely large guns I think Mr. Dundas's plan is more applicable than my own, as there might be a difficulty in casting the inner tube of a single piece. If, also, we wish to transport the pieces separately Mr. Dundas's plan is very good, but he will never succeed in making a gun bear a pressure of 8 tons per inch; whereas I believe three times that amount can be resisted by a gun constructed on the principle I discovered.

(*Notes by Captain Blakely.*)

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" On the 23rd August his Specification contains the first " allusion to rings heated and shrunk on,* and then inci- " dentally.

" On the 15th April, 1855, an Order was given by Lord " Panmure to issue a 9-pounder gun to Captain Addison, " who proposed to strengthen it by shrinking on wrought- " iron rings.

" On the 25th April, 1855, the Ordnance Select Com- " mittee was directed to place itself in communication with " Captain Blakely, relative to fabrication of guns on his " principle (vide Patent).

" 29th April, 1855, Lord Panmure ordered the Committee " to receive Professor Treadwell of the United States, who " appeared to have made some calculations relative to cast " and wrought-iron in the form of cannon.

" 25th May, 1855, an 18-pounder gun prepared on Captain " Blakely's principle (not rings on an old gun) was ordered " for proof and failed.

" 13th June, 1855, Captain Blakely brought forward cer- " tain calculations relative to the construction of guns.

" 21st July, 1855. Captain Blakely ascertains that a gun " is being prepared for Mr. Waygood, (or Captain Addison) " by shrinking hoops on it. An arrangement is made be- " tween Mr. Waygood and Captain Blakely, but the former " subsequently declares that Captain Blakely has ' stolen a " march on him'† by his representations.

* The Select Committee seems to prefer shrinking on the outer tubes to driving them on. After many trials I cannot agree with them, or look upon the shrinking method as any but a makeshift—so uncertain is the amount of contraction in cooling metal.

† I am supposed to have " stolen a march" on Mr. Waygood. In the Appendix (F) I give a letter from Mr. Needham, late managing partner of the Butterley Company, bearing testimony that they had made or were making a gun for me before I heard of Mr. Waygood. Sir Charles Fox's letter, (Appendix C) also proves that I had worked out the idea long before July, 1855, when I communicated with Mr. Waygood solely from a good-natured wish to save him from spending money on a plan so like what I had patented.

(*Notes by Captain Blakely.*)

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" The application of wrought-iron rings to cast-iron cylin-
" ders has been in use for hydraulic presses.*

" Sir Thomas Maitland states it was applied to the muzzle
" of a gun or guns in the first Chinese war of 1842. It was
" also done in the earliest war in Spain and in the Crimea.†

" The Committee are of opinion that to Captain Blakely
" is due so much of the credit of directing attention to the
" theoretical considerations connected with this subject,
" that he first placed them before the Committee in a tolera-
" bly complete form."

* Metal screws have long been used to draw corks, still the application of similar instruments to propel vessels was considered a valuable invention.

† The muzzle of a gun was broken in the Crimea and fastened on with a band of iron. Is it possible to argue that, *therefore*, there is no novelty in my plan of distributing the strain throughout the thickness of a gun?

(*Notes by Captain Blakely.*)

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APPENDIX.

APPENDIX A.

"Office of Ordnance,

11 June, 1855 $\frac{M}{1406}$

"SIR,—With reference to the late trials before the Ordnance Select "Committee at Woolwich, of an 18-pounder iron gun bored up to a 24-"pounder, and covered with wrought iron rings, constructed and fastened "in a peculiar manner of your suggestion; at which trial the gun was "burst with a charge of eight pounds of powder, I am directed by Mr. "Monsell to acquaint you that the Committee, taking into consideration "the different expansive powers of wrought-iron and cast-iron, are of "opinion that guns so constructed could never be considered safe, as "they might burst at any time, and the splinters from them would be "very dangerous, (as shewn in the late experiment) and the Committee "do not therefore recommend further experiments with guns of this "description. I beg to add that the opinion of the Committee has not "been altered by a consideration of your letter of the 30th of May, ad-"dressed to Lieut.-Col. Pickering.

"I have the honor to be, Sir,

"Your most obedient humble servant,

"J. Wood."

I received the above letter in June, 1855, the reader can imagine my astonishment 31 months later, when I received a letter (15th of January 1858), from the War Office, saying it was well-known, long before I pointed it out in 1855, that wrought-iron and cast-iron could be used together in a gun with advantage.

APPENDIX B.

Report of the Ordnance Select Committee, on Captain Blakely's mode of strengthening guns, dated 11th December, 1856.

"The enclosed summary of experiments with a nine-pounder iron gun strengthened with wrought-iron bands by Captain Blakely, shew a great amount of enduranee. In reply to Captain Blakely's letter, the Committee are of opinion that it is not desirable at present to have rings put on a 13-inch mortar for trial, but that it is preferable to have an ordinary 68-pounder of the service ringed from the breech to the trunnions in the Royal Gun Factory, to compare with Mr. Holroyd's (now in course of preparation) and with the gun of the service.

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"The Committee do not enter into the point again mooted by Captain Blakely, as to the method being his 'invention,' a claim which they do not admit, although he has the credit of having brought it more particularly to the notice of Her Majesty's Government.

"A summary of the experiments with the 9-pounder gun is herewith furnished for Captain Blakely, as requested.

(Signed) "J. Crawford Caffin, D. G. N. A."

"*Summary of Experiments with a 9-pounder Iron Gun*, 16 *cwt*, 3 *qrs.* 11 *lbs.*, *strengthened with wrought-iron rings at the breech.*

"*Weight when strengthened*, 17 *cwt.* 1 *qr.* 14 *lbs.*

Charges.

Rounds.	*Powder lbs.*	*Shot.*	*Wads.*	*Elevation.*
50	3	1	1	P.B.
36	3	1	1	P.B. to 10°
16	4	1	1	P.B. to 10°
10	4	1	1	on Skids.
5	5	1	1	on Skids.
5	5	2	1	on Skids.
36	6	2	1	on Skids.
158 Gun revented				
282	6	2	1	on Skids.
1	6	3	1	on Skids.
1	6	4	1	on Skids.
1	6	5	1	on Skids.
1	6	6	1	on Skids.
1	6	7	1	on Skids.
1	6	8	1	on Skids.
1	6	9	1	on Skids.
158	6	10	1	on Skids.
605 Total.				

"The gun burst at the 605th round into ten pieces, exclusive of the wrought iron bands, which were torn a part into five pieces. The breech complete was blown to the rear.

"J. Crawford Caffin, D.G.N.A."

A cast-iron gun of the same size was fired round for round against this gun, was revented at the same time; but burst at the 74th round after being revented, showing the great superiority of the gun whose outer parts could assist the inner.

The 10-inch and 8-inch guns made in the Royal Arsenal and now under trial, are on the model of the above mentioned gun, constructed by me. It seems incredible that in spite of this any official should claim the invention.

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APPENDIX C.

"8, New Street, Spring Gardens.
22nd March, 1858.

Dear Sir,

"I perfectly recollect having a long conversation here with you and Mr. Needham, the Manager of the Butterley Company, in March or April, 1855, and my impression was that your plans for an improved method of making cannon were then quite matured, so far as the essential point went, which I conceive to be the arrangement of the layers or concentric piles, in such a manner that they shall all share more equally in the strain, than is the case in either a cast gun, (whether of iron, bronze or steel,) or in one built up in any manner, by which the exterior is not stretched and the interior compressed as you propose. Merely soldering hoops or rings of iron or steel on a central cylinder would not give nearly so much additional strength, as you could obtain by your plan of making such hoops or rings slightly smaller than the outside of the interior cylinder, and forcing them on, or heating them and letting them shrink. "I am, dear Sir, yours faithfully,

"CHARLES FOX."

To Captain Blakely.

I must take this opportunity of acknowledging the liberal manner in which Sir Charles Fox assisted me with his advice. He had many years back made the same discovery as myself, but knowing the hopelessness of inducing the British Government to listen to any thing of the kind, had taken no steps either to publish his discovery or to lay it before the Ordnance Select Committee for condemnation. Under these circumstances the interview he above alludes to, between himself, Mr. William Needham, the managing partner of the Butterley Company, and myself, was of great service to me, giving me confidence in my own calculations, (which before I scarcely dared to trust, so wonderful did it seem that such a simple matter should have been left to me to find out), and also giving Mr. Needham such complete faith in my plan, that the Butterley Company offered to make 16-inch guns for £800 a piece. This, by the way, the War-office calls no substantial novelty, the wrought-iron 13-inch gun having cost the makers £3000!

APPENDIX D.

Letter from James Longridge, Esq. M.I.C.E. to Captain Blakely.

"18, Abingdon Street, Westminister.
"18th March, 1858.

"Dear Sir,

"I am duly in receipt of your letter of the 12th, which owing to my absence has only just reached me. I am glad to find that the authorities are at last coming round to the principle of strengthening cast-iron guns

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by wrought-iron rings shrunk on, and I have no doubt that in time they will go to the much superior system of wire coiled on under varying tension. I am, however, surprised to hear that they assert that the principle advocated by you differs in nothing from that of soldering an iron band on a cast-iron cylinder. In the first place, I may state that having been all my life practically conversant with the manufacture and treatment of iron, I have never seen or heard of soldering wrought and cast-iron together. I greatly doubt its practicability, but admitting that it can be done, *there is a most essential difference between soldering on a ring and contracting it on.* The essence of the system proposed and advocated by you, is, putting on the rings so, that when cool, they shall be in a state of tension, and the cast-iron in a state of compression, and this is, if I may so speak, the *fundamental principle* upon which we ought to proceed in strengthening guns. I need not say that in a ring simply soldered on, this principle is not called into action. The thing is too obvious to dwell upon it, and you may, therefore, most safely stake your reputation—as I would my own—upon there being an essential difference in the two modes of construction.

I am, yours truly,

"James Longridge.

"M. Inst. C.E."

Appendix F.

"Trinity College, March 16, 1858.

"Dear Sir,

"The defect which I wish to see corrected in the construction of artillery is, that almost the entire strain is thrown on a small portion of the thickness of the gun, instead of its being evenly distributed over the entire thickness. In the ordinary construction of guns in one piece, the defect is, that the inner surface bears the chief strain while the outer surface (if the metal be thick), bears little or no strain, and that in consequence, the inner surface splits when the strain is excessive, even though the thickness of the material is so great as to give an appearance of great strength. The old construction which you mention, of staves hooped round, has in like manner the defect of throwing the whole strain on the outer surface, while the staves which form the inner surface offer no resistance whatever, thus rendering the strength much less than it should be in proportion to the weight. The construction which I proposed to Mr. Mallet, when he was about to make his large mortars, and which I am sorry to see he did not fully adopt, was designed to avoid these defects by equalising the strain, so that at the moment when the highest pressure is applied, both the outer and the inner surfaces and all the intermediate rings of which the gun is composed, shall be equally

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strained. In this way it is obvious that the gun would possess the united strength of the two former constructions, and that in fact its strength may be increased at pleasure by adding on additional rings. The obvious mode of effecting this is, by tightening the external rings so as to relieve the inner ones of a portion of the strain, and to transfer it to the outer ones, which in the ordinary construction do not bear their proper share. When a gun is thus constructed it is evident that it cannot burst until the strain is so great as to split all the rings at once, and that therefore the strength will be exactly proportional to the number of those rings, that is, to the thickness of the gun, which may be increased at pleasure, while in the ordinary construction no increase of thickness adds to the strength of the gun, beyond a certain limit. The merit of this construction depending entirely on the exact distribution of the strain among the successive rings, it becomes necessary to calculate this strain with great care, since if any of the rings be originally strained too much, it will of course, split before the force of the gunpowder is sufficient to strain the other rings as much as they could bear. To guard against this danger I calculated the strains for Mr. Mallet, cautioning him that each successive ring should be put on with the exact tension that was calculated, so that when the gun was completed the inner rings might be compressed, and the outer ones strained to such a degree as exactly to compensate for the inequality of strain produced by the internal pressure of the exploded powder, and thereby to equalise the strain throughout at the moment of explosion. Mr. Mallet has, I believe, utterly neglected this caution, either because the required nicety of the operation was too troublesome, or because he thought he had obtained sufficient strength without it.

The operation of fitting on successive rings so as to press one on another accurately with a required force, is probably attended with much difficulty; but the same object may be easily attained by your method of rolling several coils of wire round a thin cylinder, taking care that the strain on each coil of wire shall be exactly equal to that which I have calculated. This cautiou is the FUNDAMENTAL principle of the construction, and has never been attended to in any gun yet made, though I have no doubt that you have approximated very closely to it in the gun which stood so remarkable a trial at Shoeburyness.

"I have not sufficient practical acquaintance with the qualities of wrought and cast iron to venture an opinion on the other question which you ask. "I am, dear Sir, yours very sincerely,

(Signed) "A. S. HART.

"To Captain Blakely, R. A."

Hearing that Dr. Hart had discovered the same method of construc-

ting guns as myself, I wrote to ask him the date of his investigations. With the utmost frankness he acknowledged that they were made after mine. At the time I thought this frankness a matter of course, but I have since been forced to doubt whether it is the rule or the exception. This doubt has had the effect of much increasing my gratitude to Dr. Hart, as also to Professor Daniel Treadwell, Vice-President of the American Academy, who made the same discovery as we did, and with frankness equal to Dr. Hart's, has written to me that *in Europe* he published the discovery after I did.

Appendix F.

Letter from William Needham, Esq. to Lieut.-Colonel Eardley Wilmot, &c.

"27th February, 1858.

"My dear Sir,

"I write at the request of my friend, Captain Blakely, to explain certain transactions which took place between him and the Butterley Company, in 1855. At that time I was a partner in the Butterley Company, but as I am not now at all connected with them, or with any other business, I beg to say that I have no personal interest in the matter in any way.

"In February or early in March, 1855, Captain Blakely called upon me at Butterley to ask whether we could undertake to make guns for him on the principle of the wrought-iron rings shrunk on a cast-iron cylinder or gun, which he informed us he had patented. He then gave us *full and minute instructions*, from which we made one for him on trial, and gave him a tender for 16-inch guns, for which I think the price was to be £800. Some time subsequently, Mr. Moser of London, applied to me for some wrought-iron rings, which he stated were to be shrunk on to cast-iron guns. Upon this application I immediately wrote to Moser to say that we could supply these rings, but that we had already been in communication with Captain Blakely for the same things, which I understood he had patented, and that I should inform Captain Blakely of his application. I did so, and thereupon Captain Blakely put himself in communication with Mr. Waygood, on whose behalf Moser's application was made. From the above facts you will at once preceive that Captain Blakely cannot by possibility have adopted his ideas from Mr. Waygood, as the Butterley Company put his gun in hand before he was introduced to Mr. Waygood, and that his (Captain Blakely's) plan was even then so far matured as to enable the Butterley Company to make an offer for the supply of a considerable number of guns."

The rest of the letter is private.

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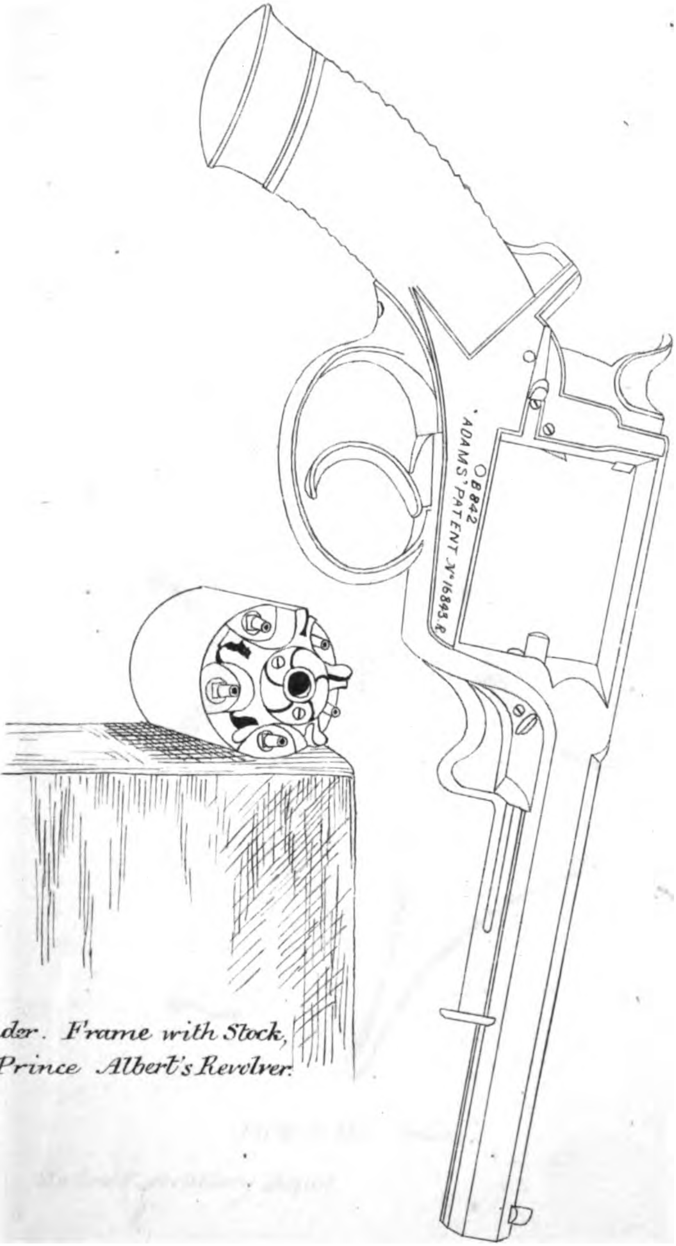
Miscellaneous.

The Revolver.



Cylinder. Frame with Stock, etc. Prince Albert's Revolver.

Madras Artillery Depôt N. S. W. E.

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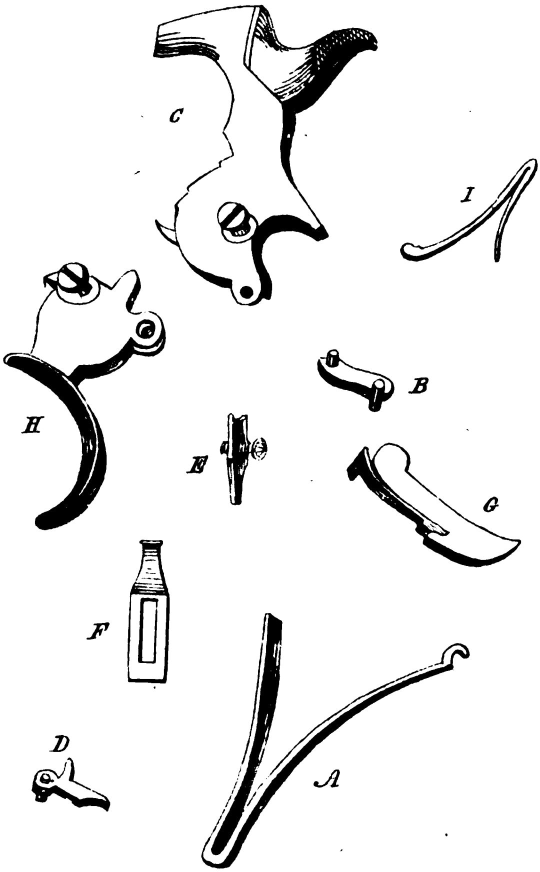
Miscellaneous.

The Revolver:



Parts of the Action.

Madras Artillery Depot N. S W. E.

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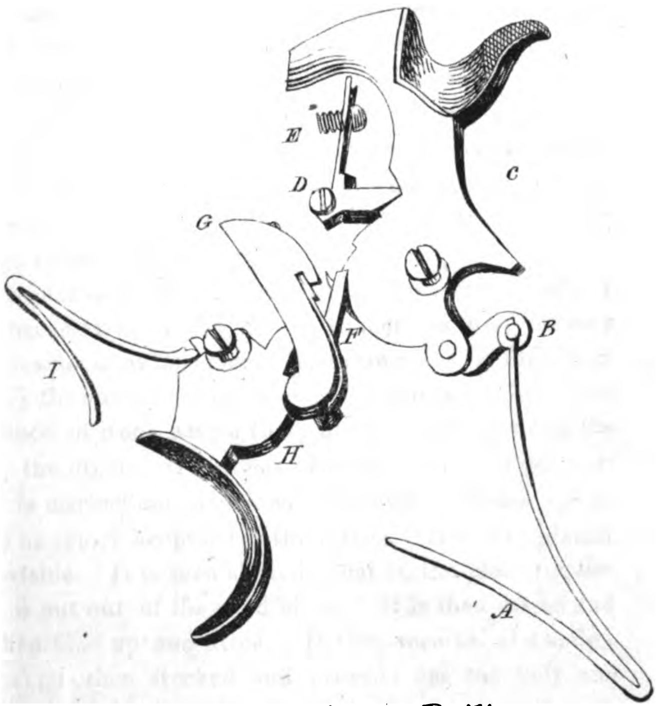
Miscellaneous.

The Revolver.



The Action in Position.

Madras Artillery Depôt N.S. W.P.E.

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THE REVOLVER.* – (Plate 46.)

Parts of the Revolver.

The parts of the Revolver are :—

1. The Frame.
2. The Cylinder.
3. The Action.
4. The Lever Rod.
5. The Furniture.
6. The Stock.

The Frame.

The Frame, which includes the barrel of the pistol, is made of a single piece of the best quality of iron that can be procured, known as Marshall's iron. It is not welded, but cut out of the solid. It has no joint in it of any kind, but is *one piece of iron.* The angles are therefore as secure as the strength of the metal can make them; and the frame being *centred* once for all, is worked true in all the after processes of boring, rifling, and fitting.

To give an idea of the processes through which the parts of a pistol are carried in the course of manufacture, we may take the frame as an instance. The frame is first forged to very nearly the outward shape which it is to retain. It is then a solid piece of iron, with a thick block at one end and the barrel at the other. It is then centred, that is, a point at each end is marked and struck as the centre of future operations. The centre keeps every thing true. It is then planed on the outside. It is then slotted; that is, the place for the cylinder is cut out of the solid block. It is then bored and rifled, then filed up and fitted. It then receives the action (lock &ca); is then stocked and proved; has the bolt and lever rod fitted; is polished, engraved, blued, screwed together, and then shot.

The Cylinder.

The Cylinder is also made of Marshall's iron, or of steel.

* Extracted from "The Revolver: its Description, Management, and Use; "with Hints on Rifle Clubs and the Defence of the Country," by Patrick Edward Dove, &c. &c.

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If of the former, it is case hardened. The cylinder is bored with five Chambers, a number abundantly sufficient for all the ordinary purposes of use. It must never be forgotten that the designing of a pattern fire-arm is a question of the compensation of advantages. On rare occasions it might be advantageous to have six, eight, or ten Chambers: more often it would be found that three or four were all that were required. It is necessary, therefore, to select out of all the numbers that which is found practically to combine the fullest measure of efficiency with the greatest amount of convenience. An odd number is required in an Adams's pistol, on account of the spur of the trigger, which comes forward when the trigger is drawn back, and fixes the cylinder at the moment of discharge. By pulling the trigger and looking at the mechanism of rotation you will observe, that when the cylinder comes to its proper place it is held firm by a projection which prevents the cylinder from revolving further. With an even number, that projection would face the open space where the cones are placed. In an Adams's pistol the nipples or cones are screwed in. In some of Colt's pistols the nipples are made of the solid metal, an arrangement which prevents the fitting of a new cone in case of fracture or injury. The central hole, through which the pin passes, is bored so as to make the cylinder touch the pin only at the two extremities, thereby lessening the friction. At the back of the cylinder is the ratchet, to give the revolving motion to the cylinder when acted on by the projecting lever of the trigger action, called technically, the *lifter*. The cylinder, when finished, is case-hardened. The ratchet is made of steel.

The Action.

The action consists of:—(Plate 47.)

A. The main spring.

B. The swivel.

C. The hammer.

D. The short scear.

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E. The short scear spring.
F. The long scear.
G. The lifter, with the spring which works both lifter and long scear.
H. The trigger.
I. The trigger spring.

The four screws or pins—hammer pin, trigger pin, short scear pin, and short scear spring pin.

The mode of action may be seen by looking at the engraving. Thus—(Plate 48.)

When the trigger is pulled the long scear pushes up the hammer, and the lifter pushes round the ratchet of the cylinder. As the hammer goes up, its circular portion, called *the belly*, pushes the long scear forward, so that it goes out of the notch, and the hammer falls on the nipple or cone. When the pistol is cocked by pulling back the hammer, the short scear goes into the full bend notch, and the long scear is pulled up close to the short scear by the hook on the hammer, which by this action draws back the trigger. When the trigger is then pulled, the long scear pushes the short scear out of the notch, and the hammer falls.

After one shot has been fired the finger must be slackened so as to allow the trigger to go forward to its original place, which it does by the action of I, the trigger spring.

This lock is not apparently simple, but it has the great merit of working well for almost any number of Shots, and does not get out of order. I believe a thousand shots have been fired with the same pistol without difficulty; but I cannot certify to the fact, not having been present.—But I have taken a pistol from the store—any one out of a hundred— and with Mr. John Adams, have shot it till we were tired—certainly above three hundred shots; and, with the exception that the pistol got a little dirty from the burnt powder, there was no appearance of its being less efficient at the end of the trial than at the beginning. The lock is excellent: to that fact I can safely certify.

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The advantages of Adam's Pistol.

The essential quality of a rifle is that it shall shoot accurately. *Accuracy* is the first requisite—to be combined, of course, with as much power, convenience, and rapidity of action as can be secured without sacrificing accuracy of performance. With the pistol it is different. *Rapidity of action* is the first quality of a pistol, to be combined, of course, with as much accuracy and range as can be secured without sacrificing rapidity. We should not value a rifle that could shoot one or two more shots in a minute if we could not depend upon the accuracy of its fire; neither should we value a pistol that could shoot very accurately at two or three hundred yards if we were compelled to spend much time and care in its adjustment every time it was fired. A pistol being required for short ranges and rapid performance, that pistol is the best which does its work most rapidly and with the fewest actions of the arm or fingers, provided it shoots with equal accuracy and power. The whole theory of the manufacture of arms is that of a compensation of advantages; and the best arm is the one in which the advantages are most judiciously combined according to the nature of the weapon. In this respect Mr. Adam's pistol excels all others that have hitherto been made. It shoots with *one* action. That, in fact, is the first requisite of a good military pistol—namely, that it can be seized with one hand, right or left, and fired in a moment with a single draw of the trigger finger. To pull up the hammer, as in Colt's, is a superfluous and most disadvantageous draw back; while a double action, as in Tranter's, is a similar error, as one cannot be expected to play the fiddle on a pistol when in action. But it is said that a pistol is more dangerous when it can be fired by a draw of the finger. Exactly; and that is the very reason that it is the best. The sharpest razor is the most dangerous for children or persons who do not know how to use it. But the sharpest razor is the best because it is the sharpest. And so it is with Adam's pistol. The very quality

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which makes it preeminently good for service is the quality that makes it dangerous in the hands of boys and bunglers. A pistol that requires two actions to fire it is more safe in a house than one that requires only a single action; one that required three would be still more safe; and one that would not go off at all, as sometimes happens with those that have complex and fanciful notions attached to them, would be perfectly safe. Adams's pistol is not constructed for what is absurdly termed safety (which is procured by *blunting the razor*), but for action—for the most rapid action that can be executed with the simplest effort. It is the elementary pistol, and the best for military service because it is elementary. To it may be added half-a-dozen new arrangements, all tending to make it more safe, and all tending to deprive it of its elementary character of simplicity, which, in my estimation, is its peculiar claim to the foremost rank among revolving arms. I do not say that it can never be improved, but that its principle is the best of all, and must be adhered to under all circumstances. But I certainly should depart very far from my intention were I to say any thing in prejudice of Colonel Colt's weapon, which is a good pistol for America and for American purposes—namely, where the pistol requires to be used as half a rifle with a long aim. Colt's pistol for military purposes is a mistake; but it is a good pistol for hunting purposes and for single shots at Indians, buffaloes, bears, and deer, though even for that service Adams's is preferable, because the *second shot*, which is often of the utmost consequence, can be given at once without taking down the pistol or going off the aim. In fact, the best way to use a Colt in a hurry is to fix up the trigger altogether and fire by snapping the hammer, in which case it becomes an inferior form of an Adams. Adams's pistol, like a Colt, can be fired from the full cock, a part of the action which was introduced by an officer in the Army; but I certainly do not consider it an improvement. The half bend is a good, useful, and necessary stop; but the full bend

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is not required, as the pistol fires more pleasantly with its own proper sliding draw than out of the full bend notch. However, some may prefer to cock the pistol when firing at a mark, and the pistol has the action, if required; but, for my own part, I think it unnecessary.

In the construction of Adams's pistol there is an advantage which many would overlook, and even gunmakers are scarcely aware of it. It is that the action of the hammer and the revolving action are disconnected. Pull back the trigger as if you had just fired, and then pull up the hammer as if the hammer had been blown up by the force of the escape from the cone, and you will observe that you have not rotated the cylinder nor set the revolving parts in action. Whenever a pistol is fired, there is, of course, a certain springing back of the hammer, and this, constantly repeated, would be apt to throw the works out of order if the hammer and mainspring (as in Colt's) were to affect the rotation of the cylinder. In an Adams's pistol the hammer and mainspring are isolated, and the hammer may be driven back as violently as possible without affecting any part of the works except the spring. And this arrangement contributes greatly to the *durability* of the pistol. It does not get out of order, which is the great drawback of other pistols.

Another advantage of Adams's pistol is that it does not shoot *all round*. When one barrel is fired it does not discharge the others; and this is the result of leaving the chamber and the nipples fully open, so that the inflamed gas is not confined and driven into the other Chambers or on the other nipples. It would be more convenient, perhaps, in case of rain to have a cover over the nipples; but the disadvantage of shooting all round would be a fatal objection. The cover was the great drawback to the first revolver introduced by Mr. Collier.

Thoroughly to satisfy yourself regarding the advantages

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and disadvantages of the various actions that are applied to revolvers, try the following conclusive experiment. A pistol, be it ever remembered, is intended for rapid work at short distances; therefore, to test the various kinds, try the following plan. Take a revolver in your hand, go to a door, open it suddenly, and snap the pistol at five different objects inside of the door. Try the plan first with the pistol in your right hand, then with the pistol in your left hand, as some doors open with the hinges to the right, and some with the hinges to the left, a circumstance which may make it of the greatest consequence to be able to use the pistol with either hand. I say that the pistol that enables you to shoot at the five objects in the shortest time, with either hand, is the best and most serviceable weapon; and unquestionably it is the single-actioned pistol that goes off with a single draw of one finger. If you are compelled to cock with your thumb, you not only lose time and are compelled to take the pistol down, but, from pulling both finger and thumb at once, you will run the risk of firing when you did not intend to fire; and if you are compelled to use your middle finger as well as your fore finger, you not only lose time and confuse yourself with alternating the draw, but you run the risk of having your middle finger cut off with a sword stroke, supposing that there are swords inside, a circumstance tolerably certain in India at the present time. To speak without reserve, I say, unhesitatingly, that no other advantage—no powerful shooting, or accurate shooting, at *long* distances—could possibly compensate, in my opinion, for the absence of the *single draw*. The single draw is the *sine quâ non* of a perfect pistol; it is the first requisite, compared with which all other qualities are of minor importance.

This point becomes more apparent when we consider the elementary qualities of the various arms—the qualities which require to be combined in certain proportions. I should therefore rank the qualities thus—

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For the Rifle.	*For the Pistol.*
1. Accuracy.	1. Rapidity.
2. Power or penetration.	2. Power or penetration.
3. Rapidity.	3. Accuracy.

The Shot Gun.

1. Proper distribution of shot,
2. Rapidity of action.
3. Power of penetration.
4. Accuracy of both barrels.

It is quite possible to make any one of these elementary qualities predominate. We can give a pistol very great power of penetration, if we are so inclined; so also we can give a rifle great rapidity. But I maintain that all exaggerations of any one quality at the expense of the others, and especially at the expense of the essential quality No. 1, ends in the production of a monstrosity, and not of a serviceable weapon. And such a monstrosity is now being sent to India in the shape of Sharp's Carbine, a weapon which, for a cavalry soldier, is, in my humble opinion, about as execrably bad as any weapon that could be designed, except that it has the one good quality of breech-loading, which, if a cavalry soldier must have a carbine, is proper and legitimate. Very long range for a cavalry weapon is about as absurb as it would be to have a shot gun that could kill snipes on the wing at 200 yards—a distance at which they might possibly be killed if they were hit, but at which they certainly never would be hit, except by accident and good luck, once in a week perhaps. Whenever, therefore, you hear of a rifle that will shoot more rapidly, or of a pistol that will shoot further, &c., &c., always ask if the essential quality has not been sacrificed.

Management.

Loading.

1. Be sure to load your pistol properly, and take pains to do it well on all occasions. The good habit once acquired, may be of vital service in time of need.

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2. To load, pull the trigger till the pistol is at half cock.

3. Hold your pistol in your left hand with the muzzle up and the butt against your chest. With your right hand place a cartridge in one of the chambers, turn the cylinder till the ball is under the rod, and force down the charge with the lever. Do the same with the other four chambers, put on the caps, and the pistol is ready for action. If the weapon is not to be used immediately, bolt the cylinder with the bolt at the side, and the pistol is safe.

If you load with loose powder instead of cartridge, be sure that the measure of your pistol flask is filled in the first place and then properly emptied into the chamber. Put in the ball, and force home as with cartridge.

Nota Bene.—Always be sure that the bullets are well greased.

Charge of powder.

For a 38 bore, or largest-sized pistol, five eighths of a drachm *at least.*

For a 54 bore, or medium-sized pistol, three eighths of a drachm *at least.*

For a 120 bore, or smallest-sized pistol, three sixteenths of a drachm *at least.*

How to burst a Revolver.

Put a pinch of powder into one of the chambers, just sufficient to drive the ball into the barrel, but not through it. Fire that charge, and the ball will stick in the barrel. Then fire a full charge, and if the thing has been properly done, the barrel will very likely be found bulged. Fire another full charge, and the barrel will bulge still more; another and the bulge will still increase; another, and possibly the barrel will be found cracked. It will be observed that *all the balls have remained in the barrel.* This artful way of bursting a pistol is supposed to have been employed at certain trials that shall be nameless.

Nota Bene.—The revolver cannot be burst by an over-charge of powder.

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How to produce accidents.

1st. How to be shot yourself. Take a revolver, loaded and unbolted, hold it by the barrel with the muzzle towards you. Hand it to your friend who is unaccustomed to the use of arms. He will very likely grasp it with his finger on the trigger, and shoot you in the left side.

2nd. How to shoot your friend. Take a revolver, loaded and unbolted, place it on your knee, if you are sitting down, hold the muzzle towards him, and begin fiddling with the lock to see how it acts. When you least expect it, the weapon will very likely go off, and you will shoot your friend from the most unpardonable carelessness and folly.

Moral.

In handling a loaded pistol, make it your invariable rule to handle it vertically; hold the muzzle straight up or down, except when going to fire. Up is the best, for down you may shoot yourself through the foot.

Nota Bene.—A Revolver is no more dangerous than any other pistol.

Cleaning.

1. Be sure to keep your pistol clean.

2. Never take your pistol to pieces. If you begin to tinker your firearms about, for the purpose of seeing how they are made, you are eminently likely to put them out of order, or to fail in putting them together again properly. The revolver does not require to be taken to pieces, but only to be cleaned after use.

3. To clean the pistol, therefore,

First—Pull the trigger till the pistol is at half-cock.

Second—Turn the little thumb-screw (technically, the fly-pin) at the side, so as to relieve the cylinder-pin; then draw the cylinder-pin, and remove the cylinder sideways from the body of the pistol.

Third—If you have hot water at hand, plunge the cylinder into it, and wipe it dry with the cleaning-rod and tow or rag;

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then oil it, both inside and out, with good sweet oil. If you have no hot water at hand, oil alone will clean the cylinder perfectly well; only take care to clear the nipples and to remove all the crust of the burnt powder.

Fourth—Do not put the *barrel* in water as thereby you might wet or steam the lock, and cause rust but clean it entirely with oil and tow. Also clean and oil the frame, especially the under part of the upper strap, where the flash takes place. Wipe and oil the hammer and the rest of the metal-work. Put in the cylinder; ram home the cylinder-pin; turn the little thumb-screw; and the pistol is ready for service.

On the Flight of Projectiles.

To the Editor of the Mechanics' Magazine.

Sir,—Having never studied any of the current works on gunnery, I am greatly astonished that the theory should have been admitted by high authorities, which Lieut. Colonel Parlby corrects in your last number, viz., that a vacuum exists behind projectiles after a certain velocity. Of what can these learned men have been thinking? Of a flight through a tube? Assuredly did a ball fly through a tube open at both ends, at a speed greater than is due to air rushing into a vacuum, there must remain a vacuum behind it, provided there is a close packing round the ball, to prevent the smallest leakage of the air, condensed to many atmospheres before it, into the section of the tube behind it. But what has this to do with the actual flight of a projectile? Where is the analogy? What has become of the atmosphere "above, below, around?" Under what mandate of *science* does it stand like a wall on the right hand and on the left whilst the children of the artillery are passing through? Is not the air a fluid pressing equally in every direction? What hinders it from closing up, from all sides in a direction at right angles to the line of flight? Even at a mathematical point behind the centre of a ball one inch in diameter, a vacuum could by

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no possibility exist longer than 1-32,000th part of a second, about the time required for air at the theoretical velocity to rush half an inch—the ball's semi-diameter. Truly these things are startling; upon such a theory, the faster a ball flew the slower it would go. Imagine a dead weight of 14 lbs. or 15 lbs. per inch of the section of a projectile constantly dragging it backwards. That the air *does* close up instantly behind a projectile at any velocity, rushing to a common centre, and causing the whistling by the concussion, I cannot see the slightest reason to doubt. I often encounter some extraordinary discrepancy between scientific teaching and practical fact, and surely this seems a powerful instance. I may be wrong; if great men make mistakes, much more may little men; but it is an undeniable truth, that nothing more hinders the progress of what is called science into the realm of practical utility, than its own inaccuracy. When it occurs to practical men, on taking up some assumed law of science, backed by high authority and testing it by experience, that it fails entirely, can we wonder at the scientific men complaining they are not listened to, or at the complaints which follow when they have been listened to? When, where, and how was the experiment ever made, which Col. Parlby rightly marks in italics, showing not only the existence of a vacuum in the open air, but a diminution of resistance from this dead weight being complete? There is a strange theory of projectiles in Tomlinson's "Rudimentary Mechanics", Weale's series. Why not try another problem? Given the velocity with which water rushes into the air under a vertical pressure of 30 feet, to find the velocity of a Ship required to leave such a vacuum (of water) at the stern, that the screw may revolve in the air.*

I am, Sir, yours &c.

(Signed) DAVID MUSHET.

July 31st 1855.

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* Mechanics' Magazine 4th August 1855.

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The Manufacture of Small Shot.

Hitherto the making of small shot from molten metal has ordinarily been performed by hand, in the following manner: At the top of a suitably high shot tower is placed a perforated dish or colander, on the upper side of which is spread a coating of scum or oxide of lead; the workman then removes a quantity of molten metal from the melting pot in a ladle, and pours the metal very gently into the perforated vessel. The metal thus poured in, a small quantity at a time sweats gradually through the skin or sheet of scum, and thus the particles become separated, and each drop falls from the top of the tower into a pool or vessel containing water. During their descent the drops of metal should become perfectly spherical; in practice, however, a considerable proportion of the whole of the drops or shots so made are found to be imperfect and unsaleable, requiring to be remelted, after having had the expense of manufacture and sorting expended upon them.

In order to remedy this defect and to make shot more rapidly than heretofore, a new process has recently been patented by Messrs. Charritie and Smith, of London, by which process the manufacture is rendered independent of the skill of the workmen employed. Instead of the perforated vessel and the coating skin or skum, as above described, the following mechanical arrangement of apparatus has been substituted. A plate of metal, of suitable thickness, is drilled with a number of holes in parallel rows, and these holes may be countersunk or made conical. This plate should be correctly faced on its under side, and may have fillets or strips of metal fixed on each side by means of screws. To these fillets or side strips another plate is screwed or attached, forming the bottom plate, and this plate has a series of holes or of parallel slots or openings corresponding with the rows of perforations or drilled holes in the upper plate. These two plates, when adjusted, have a parallel space between their faces into which another or third plate fits accurately, and is made to slide backward and forward. This third plate is of a thickness, and has holes drilled in it of a size suitable to the size of the shots

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required to be made; and these holes are drilled so as accurately to correspond with the holes in the upper plate, so that at one part of its travel the two sets of holes in it and in the upper plate, with the countersunk holes, precisely coincide. The slots or openings in the lower plate are not immediately below or opposite to the holes in the upper plate, but are about two diameters in advance of them, and they are thus fixed together and mounted on a suitable frame.

The middle or sliding plate, which may be of sheet steel, has at each end an attachment to a crank, spanner, or lever, by which it is moved backward and forward, and is stretched and held firmly like a saw in a sawing frame. Several of these sliding plates may be connected together and worked from one or more shafts, with suitable cranks or eccentrics to give the precise amount of motion or travel necessary for the purpose. Thus several sets of apparatus for making the same size, or various sizes of shots, may be fixed on suitable framings over the same pit, or within the shot tower, and they may be connected or geared together and worked by one man or by any other power, the action being as follows:—The molten metal is allowed to flow into the upper plate, around which there is a rim, ledge, or hopper, and the middle or sliding plate is caused to move, so that its holes coincide with the holes in the upper plate when they become filled with molten metal; the plate is then rapidly moved forward or backward until its rows of holes coincide with the rows of holes or the slots or openings in the lower plate, and the contents of the whole of the holes in the sliding plate fall through such slots or openings whilst in a molten state, being thus perfectly gauged as to the quantity in each of the holes, and therefore ensuring that each shot shall be precisely of the required size. Thus, each time the holes in the upper and middle plate coincide, a quantity of shots, corresponding with the number of holes in the upper plate, can be produced with accuracy.*

* Mechanics' Magazine, 13th December 1856.

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Chenot's improvements in the manufacture of Steel.

An improvement in the manufacture of Steel, the invention of M. Chenot,* has attracted attention among scientific men in France. It has already been honoured with the great medal of the Paris Exhibition, and is patented in all countries. There are four English patents, all obtained at the same time. (See *Mechanics' Magazine*, vol. 65, No. 1725, p. 211.) In the vicinity of Paris an establishment is formed, and is now producing considerable quantities of the article, and by the new method it would appear that steel of a superior quality is manufactured from iron ore with much rapidity, and at one-third of the present cost. The invention is now under examination for Austria, and the Swedish Ambassador has suggested the nomination of Commissaries. The following particulars have been communicated to the Paris correspondent of the *Times*:—

The system consists in making steel from the ore, and the principal features of the process are these:—The inventor employs, firstly, an electrosorting machine to separate the crushed ore, and to raise it to its *maximum* standard of pureness and richness—qualities which the steel subsequently retains; secondly, a system of cementation or addition of carbon and other matters *by cold process*, in such a way that this delicate operation can be repeatedly effected in determined and exact proportions, which results in the production of steel as varied in quality as can be desired, capable of being reproduced with certainty, and of identically the same temper and quality. This result is not without its importance to the consumer, as by the simple use of marks and numbers he can be sure of receiving for any given purpose precisely the same quality of steel with which he had been previously supplied. Thirdly, a compression of the ore after its transmutation, and before or after cementation into a sponge. The ore reduced into a sponge was so liable to be affected by heat or humidity, that it could hardly be kept long enough fit for compression; but

* In an article in the *Times*, this name was erroneously printed Chenol.

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in consequence of the great reduction in volume of the compressed sponge it is worked with an economy of fifty per cent in fuel and manual labour in welding, melting, &c., and thus by this second fact the value of compressing the sponge is evident. The inventor appears to have given practical proof of the commercial advantages of his system, and it is added that he sold his steel in some quantity to French manufacturers at prices which more than trebled the cost of production, without seeking the highest relative prices of Swedish steel, and could thus continue to supply steel of superior quality, not standing him in one-third of the price at which he sold it. From repeated trials, it is said that double the wear could be got out of implements manufactured of steel of this compressed sponge, compared with those made from good steel of Sheffield marks. By the same process steel can be manufactured from Spanish ore, which steel will not cost above £ 32 per ton, and be superior in quality to that sold in Paris at £ 100 per ton. In a word, the inventor secures these advantages—the manufacture of steel in ten days instead of forty, the possibility of reproducing the exact quality of steel desired, and the cost price not to exceed one third of the present price, relative qualities being borne in mind.*

Reports of Experiments on the strength and other Properties of Metals for Cannon.

Philadelphia: Baird. London: Trubner.

The bursting of the large gun on board the *Princeton* American War Steamer, thirteen years ago, caused the United States Government to institute a series of investigations on the properties of metals for cannon, a detailed report of which, so far as prosecuted, is contained in the volume before us.

The portion of the volume alloted to wrought iron is limited to a brief enquiry on the tensile strength of the iron in the unfortunate gun alluded to. This resulted in the discovery, that while the metal bore only one third the strain of English

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* Mechanics' Magazine, 7th February 1857.

bars of average quality, portions of it, when reworked, stood a tensile force nearly equal to that borne by the best hammered iron of American make. No explanation of the cause of this inferior tensile strength in the large mass appears in the report, which, in this respect, must be held deficient.

The experiments on the tensile strength and specific gravity of the metal (American) in cast iron ordnance are exceedingly numerous, and appear to have been conducted with great care. The plan pursued with all new ordnance seems worthy of imitation by engineers generally, when manufacturing castings in which a high tensile strength is demanded. Pieces of metal were taken from the gun head, as fairly representing the quality where the casting had been effected with a single charge, and turned in a lathe to the section and size fitting the testing machine. A record of the strain borne by the trial piece of each gun was kept, and forms the substance of the report. Whenever the tensile strength fell below 20.000 lbs the square inch, the quality was pronounced bad, and the gun unfit for service.

The effect of remelting the iron is shown in an augmentation of the specific gravity from about 7·000 to 7·320, and an increase in the tenacity from 20,000 lbs. to 38,000 lbs. the square inch. Although in an extensive series of experiments one or two exceptions are to be found, the dependence of superior tensile properties on a high density of the metal is very well borne out, and confirms the correctness of the views advanced by several English experimenters. But for the attainment of this high tensile strength, the iron requires to be remelted twice, and in some instances three times. An equally great improvement, however, is obtained through keeping the iron in fusion for longer periods than usual. Thus pig iron remelted and 15 minutes in fusion bore a strain of 20,336 lbs; the same iron $2\frac{1}{4}$ hours in fusion 27,456 lbs.; $4\frac{1}{4}$ hours in fusion 29,227 lbs.; $6\frac{3}{4}$ hours 36,312 lbs.; and $7\frac{3}{4}$ hours 37,552 lbs. the square inch. The density rose from 7·175 in the first to 7·343 in the last experiment.

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These figures are corroborative of the opinion expressed by M. Truran in "The Iron Manufacture of Great Britain," that mere exposure to a reverberating column of hot air, either by repeated fusions, or by a prolonged exposure, results in a refining of the molten iron through the combustion of the carbon, and partial separation of the alloyed matters. The process, however, is applicable only to dark gray varieties of pig iron; bright gray pigs bear only a limited exposure, and though their density is increased to 7,400 by lengthening the refining, their tenacity suffers a large diminution.

Some few experiments appear to have been made on the comparative strength of iron in large castings slowly cooled, and small castings cooled rapidly. The tensile strength of the former was greatest; but tested with a transverse strain, steadily applied, the small casting, cooled quickly, had the advantage.

Several guns were subjected to hydraulic pressure; and it is worthy of remark that at pressures of 9,000 lbs. and upwards the water issued from the metal in innumerable fine jets, showing that in the metal of cast-iron guns a peculiar alteration of structure took place when subjected to this pressure.

In all the experiments, hot blast iron was found greatly inferior to cold, in point of density and tenacity; so much so that in some contracts, where hot blast iron had been used, more than one-half of the guns burst under the proof fire. In no instance did the hot air smelted metal approach the tenacity essential to the durability and safety of heavy ordnance,—a circumstance which led the American Government to prohibit its use in all subsequent contracts.

With a view of ascertaining the chemical composition of the irons exhibiting remarkable qualities, a series of analytical investigations are being made; but those hitherto made in connection with the reports must be looked on as of a preliminary and undecisive character.

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A number of plates, showing the construction of the testing machines, and the fracture of the guns which gave way under severe firing, accompanies the reports. On the whole, it must be considered a work of great value to those engaged in the founding and use of iron ordnance. Our own Government, we observe, are about instituting similar experiments on the properties of English irons applicable to the manufacture of ordnance. It is to be regretted that instead of taking the initiative in an inquiry confessedly of national importance, they are found as mere copyists of the example set by the American Government. Were this the first occurrence of the kind, we should have passed it without remark; but it was only when the American Government had caused a thorough investigation of the qualities of American coals suitable for their steam navy, and the results had been published to the world, that our own Government ordered a similar enquiry to be made on English coals. Let us hope that a more enlightened policy will be adopted in future.*

Gun Cotton Cartridges.

To the Editor of the Mechanics' Magazine.

Sir,—Having read in the *Times* of yesterday an account of a gallant repulse of robbers, by the Rev. J. Hodder, I charged a horse pistol (eleven bore) with a gun cotton cartridge, weight twelve grains, and an ounce and a half of No. 2 shot; a wad of cork, about half an inch thick, formed the head of the cartridge, and a similar wad was rammed over the shot. Mr. Baker, Proprietor of the Rosherville Hotel, fired the pistol at a deal board, at the distance of ten paces. The grains of shot buried themselves in the board: there was no uncomfortable recoil from the pistol. By using gun cotton cartridges, there is this great advantage, that however long a time the fire-arm may remain charged, there is a *certainty* of fire; but with gunpowder it is quite different, as a miss-fire

* Mechanics' Magazine, 14th March 1857.

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frequently occurs from the nipple becoming clogged, and other causes.*

I am, Sir, Yours &c.

J. Norton.

Rosherville, February 24, 1857.

The Comparative merits of Wire and Hemp Ropes.

We learn from the *Liverpool Mercury* that a set of experimental tests was recently instituted to ascertain the comparative strength of wire and hempen ropes for the standing rigging of ships. The experiments were made at the corporation testing machine, King's Dock, Liverpool, and were witnessed by several merchants, shipmasters, and professional riggers. Besides the test of strength, there was also a trial to find the best method of fastening the dead eyes in wire ropes, whether by splicing or "turning in." The ropes of wire, hemp and Manilla were all of the manufacture of Messrs. Garnock, Bibby, and Co.

The following are the sizes and materials of the samples subjected to experiment, with the results:—

			T.	C.
$3\frac{3}{4}$ inch galvanized wire rope,	broken at	...	20.	15
$3\frac{3}{4}$ inch Manilla hemp,	ditto	...	5.	17
$3\frac{3}{4}$ inch Russian hemp,	ditto	...	4.	15
$3\frac{1}{4}$ inch galvanized wire rope,	ditto	...	16.	10
$2\frac{1}{4}$ inch galvanized wire rope,	ditto	...	8.	10

There were also some experiments made with soft and hard wire rope.

The testing of the hempen ropes, proving the strength of Manilla to be so far superior to Russian hemp, took many by surprize. It was explained that the method of Messrs. Garnock, Bibby, and Co., in manufacturing Manilla, adds greatly to the strength of the rope. All their ropes are machine spun—a method which admits the whole of the fibre to be extended at full length, and the

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* Mechanics' Magazine, 14th March 1857.

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strength of the material obtained, whereas hand spinning does not admit of the like advantage. The straining tests shew the immense superiority of wire rope over that made even of the best fibrous material; but this is not the sole advantage it presents. Wire rope is a fourth less in weight, and not one-half the bulk of that made of hemp of the relative strength and enduring capacity. The advantage of this, especially in ships beating to windward, needs no comment. Moreover, the cost is 25 per cent. in favor of wire rope over hemp, estimating weight and saving. Again, wire rigging is much less susceptible than hemp of atmospheric changes, and needs no stripping or refitting. Wire rope seems destined to surpass, if not supersede, hemp rope in ships' standing rigging. Three-fourths of all the vessels now rigged in Liverpool are rigged with wire rope, Messrs. Garnock, Bibby and Co. alone having either fitted or in orders twenty-three vessels for wire rigging during the present year.

From the experiments it appears that splicing is the best mode of fastening the dead eyes in wire rope.

The experiments made on the comparative resistance of hard and soft wires were greatly in favor of the hard wire. The hard wire was found to bear 60 per cent. greater strain than the soft. Both wires were the same, the one remaining precisely as when drawn, the other having been annealed. The annealed is the most pliable for splicing, but being found so much weaker, the decision was, of course, in favor of the hard wire.

The result of the testing, on Monday, shows that English energy and skill have been, as heretofore, crowned with success. Better and cheaper substitutes than Russian hemp have been found for those works of which it formed the great staple. Manilla, so much stronger—as the tests establish—is also one-fourth lighter, and much cheaper, than Russian hemp; besides, it does not require tarring, and consequently must run more freely through the blocks.

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During the war with Russia, and the consequent dearness of hemp, Garnock, Bibby and Co. manufactured rope from cotton, and also from coir yarn. The latter is still used extensively, is found to wear well, weighs but little, and costs not more than about one-third of the price of Russian hemp rope, It has great elasticity, and on this account appears particularly well adapted for hausers, warps, and such like.*

Remarks upon the Diaphragm Shrapnel Shell By Captain E. M. Boxer R. A. Superintendent of the Royal Laboratories.

As I am aware that much misapprehension still exists upon the subject of the Diaphragm Shrapnell Shells, and particularly as regards the main object of the experiments now being carried on under the direction of the Ordnance Select Committee—notwithstanding the explanations afforded in my Memo. of the 8th February,—I deem it right, for various reasons, to give a full account of all that has taken place in relation to this important subject, and to answer the many objections which have been, or are still, raised by those who are opposed to, or misunderstand, the system; and I wish specially to remark, that I have throughout my enquiries and experiments never deviated from the principles which were at first advanced, and that the alterations which have from time to time been made, are simply those which resulted from the information gained by the trials carried on with a view of perfecting the system. And, indeed, some modifications, as the deepening of the grooves in the shell, and the quantity of powder for bursting, were early indicated.

I have already stated in the Memo. above mentioned, that my first proposition to separate the powder from the bullets in Shrapnel Shells, was made in 1849, when I first became aware of the cause of the serious failures which so often occured in practice with the projectile as arranged by General Shrapnel—and that, in 1852 I submitted the particular plan of separation carried out in the present Diaphragm pattern.

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* Mechanics' Magazine 15th August 1857.

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The following letter, addressed to the Secretary of the Master General of the Ordnance, clearly shows the object, and the only object, I had in view, at that time, in making this great alteration in the original construction.

"Royal Arsenal, 10th May, 1852

"SIR,—I have the honor to call His Lordship the Master "General's attention to the very great defect which still ex- "ists in Shrapnel Shells, particularly in those of larger natures, "viz., their liability to explode in the bore of the gun. This "subject has engaged my attention for the last three years, "and the increasing importance of this weapon, has induced "me to endeavour to devise a means whereby the above im- "perfection may be overcome.

"After my proposal of the new Fuze, experiments were "carried on at Woolwich, in order to determine the cause of "the "premature bursting" which so frequently took place. "It was then proved, beyond all doubt, that, however per- "fect the fuze might be, premature bursting would still "happen, not only with the full service charge for solid shot, "but also when the powder was considerably reduced in "quantity.

"It further became evident that the shell was sufficiently "strong, in itself, to withstand the shock received from the "powder in the gun.

"These points being determined, there could only remain "two other probable reasons for the failures.

"1st The percussion or friction of the Musket Balls might "evolve sufficient heat to ignite the bursting powder.

"2ndly. The Fuze might be driven out by the reaction "of the bullets in the shell.

"With regard to the 1st.—There cannot be a question "that this is the principal cause of failure, for I have myself "seen several shells which were filled with balls and the "bursting powder, but without fuzes, (the hole being plug-

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" ged with wood), explode on striking the Butt, and in these " cases the powder could only have been ignited by the action " of the bullets in the interior.

" The second probable cause I believe has never been fully " investigated, but in all probability it is one cause of failure, " particularly when the shell has no " lip" as at present, for " the material of which the Musket balls are composed has a " certain amount of elasticity.

" The defect from this might very easily be overcome, " either by having a bottom to the fuze hole (perforated to " communicate the fire from the fuze to the bursting pow-" der), or by having a screw fuze. With wooden fuzes the " former would be perhaps the best plan; but in order to " overcome the imperfection in the projectile from the first " cause, namely—the ignition of the bursting powder by the " friction or percussion of the bullets—I have the honor to " propose two methods:—the one being applicable to large " shells, and the other to those of the smaller natures.

" 1st. That in all Shrapnel shells, from the 24 pounder " upwards, the powder be separated from the balls by means " of a wrought iron partition. This partition could be " placed in the core when the shell is cast. I do not con-" ceive that there will be any practical difficulty in manufac-" turing a projectile of this description; but, if there be " found any, the same principle may be accomplised in some " other way.

" In order that the shell may burst in such a way as to " release the Musket balls, so as to obtain the greatest amount " of effect, it would be advisable, on account of the position " of the powder, to weaken the shell in certain parts, by " having 4 grooves either on the exterior or interior of the " projectile. The proper depth of these grooves can only " be determined by experiment.

" To reduce the quantity of powder requisite to burst the " shell, I beg also to propose a Metal Screw Fuze according

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" to the enclosed drawing, which would also be applicable " to a shell of any construction.

" 2ndly. That in the 12 pounder, 9 pounder, and 6 poun- " der shells, I have the honor to propose, that the Balls be " made of a substance a little harder than lead,—viz., of an " alloy similar to type metal; and in order to reduce the " friction as much as possible, that both these and the interior " of the shell be coated with Plumbago, (which may be ac- " complished by the plan employed with small shot for fow- " ling pieces), and after placing as many balls as is convenient " in the shell, that they be completely jammed together by " a conical plug or otherwise, and that a separate small hole " be made for the purpose of putting in the bursting powder.

" I hope that His Lordship the Master General will con- " sider the importance of the subject as an excuse for my " again bringing it forward.

" I have &c.

(" Signed) E. M. Boxer, Capt. R. A."

When my proposition was referred, by the Master General, to the Select Committee, I was requested to attend the Committee to afford any explanation that might be required. I well recollect that at the interview I then had with the Committee, two grave objections were urged against the arrangements I proposed, and they were similar to those mentioned at page 6 of my Memo, namely,—that the projectile being " eccentric" great irregularity in " flight" must result, and that owing to the powder being on one side of the bullets, their velocity and proper direction of motion would be considerably affected—and I believe, that, had it not been for a strong recommendation for a trial made by one member of the Committee, my proposition would have been rejected at once. However, 12 8-inch shells were ordered to be made for experiment, and in the autumn of 1852 the trial was carried out under the superintendence of the late Colonel Robe, at Shoebury Ness. The results of this trial were in the highest

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degree satisfactory, and proved that the above objections were entirely groundless, as may be seen from reports upon the subject.

On the 29th March, 1853, I wrote the following letter to the Director General of Artillery, in which I again clearly defined the object of the construction:—

" Royal Arsenal, 29th March, 1853

" Sir,—Not having heard any thing, officially, about the " Diaphragm Shell proposed in May 1852, and experimented " upon in October 1852 with complete success, I fear that " there exists some misunderstanding with regard to the " object aimed at by me in this proposal, and that it has been " mixed up with the Fuze question:—I have the honor to " state that this suggestion has no reference whatever to Fuzes, " as the principle involved is independent of that subject; " for, whatever may be the nature of the fuze, it will be im-" possible to fire the larger natures of Shrapnel shells with " large charges, and even with low charges much uncertainty " will always exist.

" Now with the Diaphragm shell, I feel confident, from " the experiments which have been already made, that the " effective range of this description of projectile may be " doubled, and that no uncertainty will exist as to their effect, " provided they are properly constructed.

" Of course before any conclusion can be arrived at upon " this subject, it will be necessary to make further experi-" ments, and I think 200 shells fired from the 68 pr., " 56 pr., 32 pr., and 24 pr., with the full service charge for " solid shot, will be sufficient to test the value of the pro-" posal.

" I beg also to state, that my present wood Fuze may be " adapted to this construction of shell.

" As I can only be away from Woolwich in June and July, " it will be necessary, if the Committee consider it desirable

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" to carry on the experiments, that the shells be ready by
" that time.

" I have &c.

(" Signed) E. M. Boxer, Capt. R. A."

On the 1st April 1853, I was requested to send drawings of the 8-inch and 24-pounder Diaphragm shells, and on the 7th of the same month I forwarded drawings to the Committee, in which the partition or diaphragm was placed so as to reduce the original size of the powder chamber. One hundred 8-inch, and one hundred 24-pounder shells were made according to these drawings, and in August and September 1853, a series of trials were made at Shoebury Ness, under the direction of Colonel Lake. At the completion of the experiments, I addressed the director General of Artillery as follows:—

" Royal Arsenal, 27th September 1853.

" Sir,—The experiments with the 8-inch and 24-pounder
" Diaphragm shells having now come to a close,—I have the
" honor to make a few remarks upon the subject.

" The following are the Shells which have been fired this
" season, with the charges &c.

	No. of Shells.		Nature of Gun	Charge.
"	12		from 68-pounder, 112 cwt.	20 lbs.
"	2	..	ditto	16 "
"	2	..	ditto	14 "
"	2	..	ditto	12 "
"	72	..	8-inch of 65 cwt.	10 "
"	10	..	8-inch Howitzer.	4 "
"	81	..	24-pounder of 50 cwt.	8 "
"	10	..	24-pounder Brass Howitzer	$2\frac{1}{2}$ "
"	191 Total			

" Out of the whole of the above number of shells, there
" has not been a single failure from premature bursting.

" When I first proposed the diaphragm shell, there were
" two objections brought against it—the first was, that from
" the construction of the projectile, the accuracy of fire would
" be greatly interfered with; and the second, that from the
" arrangement of the bursting powder, &c., the balls would

" be thrown either to the one or the other side of the trajec-
" tory.

" During the practice this year, and last, I have drawn " particular attention to these two points, and it was observed " that, instead of the accuracy of the fire being diminished, " the practice has been better than with ordinary round shot, " and moreover, that the spread of the balls has been symme- " trical with regard to the trajectory; this was no more than " what I expected, for in constructing the shell, and in ar- " ranging it for service, my aim was to obviate any defects of " this sort.

" When I first became aware of the cause of premature " bursting in shrapnel shells, and saw that the only method " of altogether preventing this serious defect, was the sepa- " ration of the powder from the bullets—my first idea was " to place the powder in a cylinder in the continuation of " the fuze-hole, but I at once perceived that there would be " a very great objection to such an arrangement, particularly " in the larger natures of shells; for the bursting powder in " order to cause rupture in the shell, must act through the " balls, and thereby cause a very great spread in all directions, " which would be contrary to the fundamental principle of " the action of shrapnel shells. It then occurred to me that, " by placing the powder in front of the balls, and at the same " time weakening the shell in a particular manner, viz., by " grooves, the powder would not be acted upon by the bullets " at the moment of the explosion of the charge, and that the " bursting powder would act as it were from the outside of " the mass of balls, and thereby not only cause a small lateral " spread, but also that the spread would not be materially " different in whatever position the shell might be at the " moment of bursting; and I am now of opinion, that upon " these grooves depend in a great measure the success of the " system.

" The point above all others which appears to me to shew " the value of the principle of the Diaphragm Shell is, that

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" it was successful from the very first, and that it required no " alteration from the original design; and I consider that I " am now in a position to construct shells, *of all natures*, both " small and large, which, with ordinary care, will answer all " the requirements of the service.

" There is, however, one defect which I noticed in the last " experiments, viz.—that the clay which was placed between " the bullets to prevent them from conglomerating, had the " opposite effect. I therefore propose,—1stly that the bullets " be made harder, by mixing antimony with the lead; and " 2ndly. That powdered charcoal be substituted for the clay.

" Forty of the Diaphragm shells were fired with the two-" channel wood fuzes of my construction, with perfect suc-" cess; and from the quickness and simplicity of the prepara-" tion of these fuzes, combined with the certainty of their " action in *whatever hands* they may be placed, I beg to pro-" pose that these fuzes be used for all natures of Diaphragm " shells.

" Should the Diaphragm Shell be adopted into the service, " in order to prevent delay, it would be advisable to keep to the " present construction; but experiments might afterwards " be made to discover whether increasing the depths of the " grooves might not operate favourably; I am of opinion " myself that it would do so.

" As there are a great number of Shrapnell Shells now in " Store, I beg to state that, having now for so long a time " turned my attention to the subject, I can with confidence " undertake to prepare these shells in such a manner as to " prevent the defect of premature explosion, although it will " be impracticable to make them as efficient as the Diaphragm " shell.

" (Signed) E. M. Boxer, Capt. R. A.

And on the 11th October I received a letter from the Secretary of the Master General, transmitting a copy of the Report of the Select Committee.

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The following are copies of the letter and report:—

(Copy)

"Office of Ordnance,
11th October 1853,

"SIR,—The Master General having had before him the "Report of the Select Committee, dated the 1st instant, on "the subject of your Diaphragm Shrapnel Shell,—I am "desired to transmit to you a copy of this Report, and to "acquaint you that His Lordship has approved of the several "recommendations which it contains; and I am at the same "time commanded to convey to you the Master General's "best acknowledgments for the zeal and ability with which "you have applied yourself to the improvement of the Shrap-"nel shell.

"I have &c.
"(Signed) EDWARD ELLIOTT,
For the Secretary

"Captain BOXER,
Royal Artillery."

REPORT OF THE COMMITTEE.

"1st October 1853.

"With reference to their Report, 18th April, 1853, recom-"mending further experiments with Captain Boxer's Diaph-"ragm Shrapnel shells,—I have the honor to inform your "Lordship that 186 of these shells have since been fired at "Shoebury Ness, with very satisfactory results.

"It appears by the minutes of the Committee, that an ex-"periment was made on the 17th September 1849, with "Shrapnel shells having the bursting powder enclosed in "canvas bags, so as to separate it from the balls.—This mode "of preparation was suggested by Captain Boxer, to prevent "liability to premature explosion from the friction of the "balls within the shell.

"In consequence of the favorable result of the experiment, "Captain Boxer, on the 10th May 1852, proposed that

" Shrapnel Shells, from the 24-pounder upwards, should be " constructed with a wrought iron plate, for the purpose of " separating the powder and the balls.

" Twelve 8-inch shells of this construction were fired last " year from an 8-inch gun, 65 cwt., with 10 lbs. charges, and " 186 shells have been fired this year without a single pre- " mature explosion viz.

	Charge.	Round.
" In 1852 from 8 inch Gun, 56 cwt....	10 lbs.	12
" ... 1853 ... ditto...	10 "	70
" ... 1853 ... 8 inch Howitzer...	4 "	9
" ... 1853 ... 68-pr. Gun, 112 cwt.	12 "	2
" ... 1853 ... ditto	14 "	2
" ... 1853 ... ditto	16 "	2
" ... 1853 ... ditto	20 "	12
" ... 1853 ... 24-pr. Gun, 50 cwt.	8 "	79
" ... 1853 ... 24-pr. Howitzer	2½ "	10
	Total Rounds...	198

" The shells from the 68-pounder having been fired with " heavy charges, the musket balls, in some instances, were " found conglomerated with the clay.

" There was little fusion of the lead balls in the other shells, " and Captain Boxer proposes that the bullets be made harder " by mixing antimony with the lead, and that powdered " charcoal be substituted for the clay.

" Forty of the Diaphragm shells were fired with Captain " Boxer's wood fuzes, the remainder with metal fuzes.

" The Committee consider that the result of this experi- " ment is highly satisfactory, and having given much consider- " ation to the subject of Shrapnel Shells, the various kinds " that have lately been tried, and the unsatisfactory state of " those now in the service—beg leave to recommend that the " 8-inch, 32-pounder, and 24-pounder Shrapnel shells requir- " ed for the service next year, may be constructed of Captain " Boxer's Diaphragm pattern.

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" The Committee have no reason to doubt that the same " pattern will answer as well for the smaller natures of shells, " and therefore recommend that 200 12-pounder, 200 9-poun- " der, and 200 6-pounder Diaphragm Shrapnel shells may be " made for experiment at the earliest opportunity, with a view " to their introduction into the service.

" With the Diaphragm Shrapnel shell the service charges " for shot can be used—the longitudinal spread of the balls " is very great, and the direction good. The effective range " with the 68-pounder gun, with 20 lbs. of powder and 6½° " elevation, is upwards of 2,500 yards, and those of the 8-inch " gun and 24-pounder gun at 5°, 1,700 yards.

" The Committee desire to congratulate Captain Boxer " upon the success which has attended his efforts to improve " the Shrapnel shell.

" Your Lordship had an opportunity of witnessing some " of the practice at Shoebury Ness, and the Committee beg " leave to draw your Lordships' attention to the zeal and " talent which Captain Boxer has displayed in rendering this " valuable projectile so efficient.

" (Signed) W. Cator, D. G.

The results of these trials were certainly most conclusive as to the value of the principle I had adopted in the construction of the Diaphragm shell; and nothing more was required to insure to the service a Shrapnel shell, possessing all the advantages of the original invention without its almost fatal defects, than some experiments, for the purpose of determining the *most suitable* arrangement in regard to the details of construction, as recommended in my letter of 27th September.

In regard to the recommendation of the Committee, " that " 200 12-pounder, 200 9-pounder, and 200 6-pounder Diaphragm Shrapnel Shells may be made for experiment at the " earliest opportunity, with a view to their introduction into " the service":—In the early part of December 1853, I for-

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warded drawings of the different natures of shells, from the 6-pounder to the 8-inch, with a request that, as the 6-pounder, 9-pounder, and 12-pounder were experimental shells, only 50 of each of them should be made at first; however, owing to the great press of work consequent upon the late war with Russia, the above suggestions of the Committee were not carried out at the time. But on account of the great success which attended the experiments in 1852 and 1853, it was considered desirable to adopt the Diaphragm pattern in Shrapnel shells of all natures which were required for the service in 1854 and 1855, and consequently a large number of these shells were contracted for.

In the autumn of last year, it was decided that the experiments suggested by the Committee in 1853 should be carried out at once, and the trials which are now being made have exclusive reference to this recommendation:—the special object being to test the principle of construction when applied to shells of the smaller calibres—in fact, to determine whether the 12-pounder, 9-pounder, and 6-pounder shells of the Diaphragm pattern possess the advantages pointed out by the Committee, as existing in the larger calibres, and claimed by the inventor.

Although the recorded results of the experiments of 1852 and 1853 are sufficient to show the fallacy of the chief arguments which have been urged in condemnation of the Diaphragm Shrapnel Shell, I am prepared to prove, by the simple principles of mechanics, that the objections brought forward are based upon an erroneous hypothesis, and have therefore no real value.

First then,—It has been often stated, and it is, I believe, the opinion of many even at the present time, that, as the centre of gravity in the Diaphragm shell does not coincide with the centre of figure, owing to the relative positions of the bullets and bursting charge, or in other words, as the projectile is "eccentric", great irregularity in flight must result.

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Now, there is no foundation for this opinion, either in fact or in theory. There can be no doubt that if a spherical projectile, in which the centres of gravity and figure do not coincide, be *placed accidentally in the bore*, that irregularity, and perhaps great irregularity, in flight, will result; this, however, will not be the case when the line joining these two centres is placed always in the same relative position with the axis of the bore, but, on the contrary, less irregularity will occur than with ordinary round shot; and the reason of this will be clearly seen, if we consider the effects produced upon an "eccentric" projectile in the bore of the gun, and during its passage through the atmosphere, when it is placed in various positions with reference to the line joining its centres of gravity and figure.

In the first place, if a body at rest, but free to move, be acted upon by a force passing through the centre of gravity, a progressive motion, or motion of translation in the body, will only result; but if the force does not pass through the centre of gravity, then besides a progressive motion, the body will acquire a motion of rotation round an axis passing through the centre of gravity, and perpendicular to a plane containing the line representing the direction of the force and this centre.

Now, if a spherical "eccentric" projectile be placed in the gun, so that the line joining its centres of gravity and figure forms an angle with the "axis of bore," it is clear that the line representing the sum of all the forces, resulting from the explosion of the charge, will not pass through the centre of gravity, as it passes through, or nearly so, the centre of figure; and the result will consequently be, as stated above—a motion of rotation round an axis at right angles to the axis of the bore.

The application of this fundamental mechanical principle to the case in point, may be popularly illustrated as follows:

Suppose two hemispheres—the one of lead and the other of wood—to be placed in the gun as shewn in the figure.

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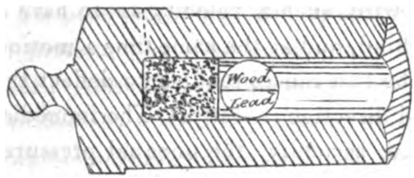


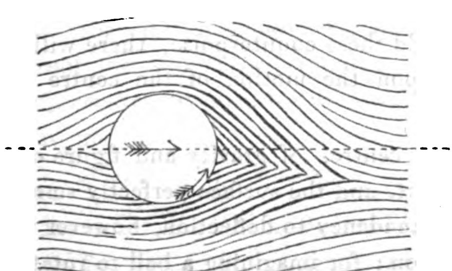
When the charge is ignited, a certain and equal pressure will be exerted upon each of the two hemispheres; but as the one hemisphere, namely, that composed of wood, is less in "mass" than the other, it will, according to a mechanical law, separate from, and be projected with greater velocity than, the hemisphere of lead; but if the two hemispheres are inseparable, then a motion of rotation from above downwards will be generated, together with a motion of translation.

This is an exaggerated case, but the same effect will be produced, namely—a motion of rotation—if the centres of gravity and figure are not in a line with the axis of the bore, or in a straight line parallel to this axis.

The next point we have to consider is, the effect which a rotation of this sort will have upon the path of the projectile in the atmosphere.

The following extract from my Treatise on Artillery, page 165, paragraphs 344, 345, and 346, will explain this:—

"Let the diagram below represent a shot whose centre of



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" gravity coincides with its centre of figure, moving in the " atmosphere with such a velocity as to have a very small " pressure behind, and at the same time a motion of rotation. " There will be two causes tending to deflect the body from " the required direction :—1stly. The immediate action of " friction; and, secondly, the unequal pressures on the top " and bottom of the fore part of the shot, owing to the " variation in the density of the medium produced by the " friction. If a ball rotates in a fluid, unless it be perfectly " smooth, there will be a certain amount of friction upon " the surface. Should this force act upon different sides of " the centre of gravity equally, it will have no tendency to " produce any change in the direction of the ball's motion; " but will merely affect the angular velocity. On the con- " trary, if this force act upon different sides unequally, it " will tend to change the direction of the motion of the " centre of gravity.

" In the case represented in the diagram the fore part of " the ball will experience more friction than the hind part, " where there is a vacuum, or nearly so; and, the direction " of this force being downwards, the range of the ball will, " on this account, be diminished. But, as the ball rotates " in the direction indicated by the arrow, the friction will " cause the medium to be more dense on the bottom side " than on the top, and this denser medium acting upon its " oblique surface near the bottom will tend to elevate the " ball. Consequently the friction will have two tendencies— " the one to diminish the range, the other to increase it; " and should these counterpoise, there will be no effect pro- " duced upon the motion of the centre of gravity of the " ball.

" If the centres of gravity and figure of the shot were " coincident, and the surface perfectly smooth, there would " arise no tendency to deflection, however rapid the velocity " of rotation; for imagining a ball to rotate round an axis " passing through the centre of gravity, and the latter point

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" to be at rest, it is evident that this motion will have no " effect upon the particles of air, and consequently, by the " third law of motion, the atmosphere can have no effect " upon the ball. Friction, then, is the only immediate " cause of deflection in a projectile whose centres of gravity " and figure are coincident. But when the ball is eccentric, " if there were no friction, still, would the rotation have a " disturbing effect upon the flight of the projectile; for in " one revolution the resultant normal resistances will make " an angle with the direction of translation, and thereby " affect the path of the shot.

" The diagram represents the probable *relative* motions of " the particles of the air, and it will serve to show more " plainly than could be explained in words, the peculiar " effect which this motion of rotation will have upon the " flight of a ball. If the anterior part of the shot turn " from below to above, there will be a force tending to raise " the centre of gravity, and the range will be increased; if " from above to below, it will be diminished. Should the " rotation be from right to left, the deviation will be to the " left; and if from left to right, the shot will be thrown to " the right."*

I have thought it desirable thus fully to explain the cause, and effect of rotation in a spherical projectile, on account of the great misapprehension which exists in regard to the matter, as manifested by the repeated and continued objections made to the Diaphragm Shell on account of its eccentricity.

It must be seen, from the above remarks, by any person who can comprehend the simple and fundamental laws of mechanics, that if eccentric projectiles be always placed in the gun in similar positions in regard to the lines joining their centres of gravity and figure, *whatever that position may be*, that their path will be more regular than that of ordinary

* When it is said from above to below &c., it refers to the front portion of the projectile.

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round shot placed accidently in the bore; and the results of the experiments which were made in 1850 and 1851, at Shoebury Ness, notwithstanding the imperfect mode adopted to secure the proper position of the eccentric shot, confirm this view.

But although the Diaphragm Shrapnel Shell, when prepared for service, is, from the relative positions of the bullets and powder, what is termed eccentric, still no rotation will be generated in the bore from this arrangement, as the wood bottom, which is firmly riveted to the shell, always ensures the straight line which joins it centre of gravity and centre of figure, being in a position parallel, or very nearly so, to the axis of the bore, or the line representing the direction of the propelling force; so that, in fact, the flight of these projectiles should be theoretically more accurate than ordinary round shot of the same weight, and I am quite satisfied that in practice it will be quite as accurate.

We now come to the second objection, namely, that owing to the bursting charge being on one side of the bullets, their velocity and proper direction of motion must be considerably affected.

Sufficient explanation in relation to this point is afforded in the appendix; and I have only to add further, that by careful experiment it appears, that the action of the bursting charge, in giving motion to the bullets, even under the most favorable circumstances, is only sufficient to indent pine wood, when placed about five feet from the shell, on an average from two to three hundreths of an inch. If we consider this fact in conjunction with the following, that—even at a considerable range, when the shell is fired with the maximum charge for round shot, and burst at five feet from the target, the bullet will penetrate several inches,—it must be acknowledged that this objection is, to say the least of it, groundless.

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It has been stated, repeatedly, that the bullets from the Diaphragm Shell often fall "dead" immediately below where the projectile bursts; or, in other words, that the remaining velocity of the bullets is *nil*, and that this is the case when the fuze is uppermost at the moment of explosion. With regard to this, I have only to remark, that a very slight mechanical investigation would show that such an effect could not possibby have been produced under any circumstances.

It sometimes happens that the effect of the bullets which have struck the target, even at a comparatively short range, is very inconsiderable—being only sufficient slightly to indent the wood. But the conclusions in relation to the action of the bursting charge upon the bullets, which have been drawn from this fact, are entirely erroneous; and it does not require much discernment to see what is the real cause of this *apparent* non-efficiency of the contents of the shell.

When the bursting charge disengages the bullets from the spherical case or shell, although, according to the principle of the "conservation of the centre of gravity," the *centre of gravity* of the mass, which is composed of the iron shell, the bullets, and the gunpowder, will not be affected in its motion except by the effects of some external force, but will proceed in the same course as the projectile would have done if it had not burst—still, the bullets are dispersed slightly, and generate in their motion a curved cone, if it may be so called, the apex of which is at the point of explosion.

If the elevation of the gun be correct in regard to the object fired at, many of the bullets will strike the target before they touch the ground, whilst others will strike the ground, and ricochet from it on to the target—these latter, however, will, particularly if the soil be soft, have lost the greater, part of their velocity, and, perhaps, merely indent the target or lodge in it. If the elevation, however, deviates very much from what it should be, the bullets will either clear the target altogether, or, in the case where the elevation is too little

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strike the ground in front of the target, and ricochet on to it, or perhaps penetrate into the soil. It is clear, therefore, that the simple fact of the bullets not having a due effect upon the target, apart from other considerations, is no proof that the bursting powder has affected their velocity; and moreover, if the indentations made by the bullets on the targets, or the bullets which have merely lodged, be examined, it will not require much science to determine the true cause of their not penetrating, for many of the indentations will be found to be of a form that could only have been made by bullets proceeding in an *upward direction*. There will, no doubt, be found marks not of this form, as some of the bullets will strike the target, after they have grazed, when they are descending from the highest point of their curved path.

It may be safely affirmed, in relation to the Diaphragm shell, that if one bullet be found effective in regard to penetration, that every bullet in that shell would have been equally effective if it had struck the target before coming in contact with any other substance.

In my Memo already referred to, (see appendix), I pointed out the conditions I endeavoured to fulfil in designing the Diaphragm pattern, namely,—

First.—THAT THE SHELL SHALL RESIST THE SHOCK FROM THE EXPLOSION OF THE FULL SERVICE CHARGE and

Second—THAT THE BULLETS, WHEN RELIEVED, SHALL BE BUT SLIGHTLY AFFECTED IN THE DIRECTION OF MOTION OF THE SHELL, BY THE ACTION OF THE BURSTING CHARGE.

I also explained the reasons which induced me to consider these conditions a desideratum. The latter condition embodies General *Shrapnel's* grand principle, and which was attained to a considerable extent in the original construction; but, in the Diaphragm pattern, as actual experiments will shew, this condition is fulfilled in a still higher degree—in fact, I believe it is considered by some that the bursting pow-

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der does not disperse the bullets sufficiently. However, I am not of that opinion; but, if required, the spread can be increased.

If horizontal dispersion of the bullets could be attained without vertical dispersion, then, a greater dispersion than what is now caused by the bursting charge in the Diaphragm Shell, would be advantageous; but as this cannot, by possibility, be accomplished, the mere opening of the spherical case is all that is desirable; for if the bullets were much affected by the bursting charge, little effect would be obtained from the use of the Shrapnel Shell in actual warfare.

Other objections, besides those already mentioned, have been, and, I believe, are still advanced against the arrangement carried out in the Diaphragm pattern, and they have reference principally to the manufacture of the shell.

Now, upon this point I may be permitted to speak with authority, as in my capacity of Superintendent of the Royal Laboratories, it is my special duty to devise and carry out such a system of manufacture as shall insure, as *far as practicable*, to the Naval and Military Services, a due and efficient supply of a certain class of "war materiel"—and the Diaphragm Shell belongs to this class.

The following are the objections referred to:

First.—That a complete separation of the powder and bullets cannot be effected by the Diaphragm arrangement.

Second.—That the shells will not continue to be for any length of time in store in a serviceable condition.

Third.—That the effect caused by the jolting action in travelling in limber boxes, will render the shells inefficient.

Fourth.—That owing to the skill and care requisite to cast the shell correctly, being so great, the expense of manufacture will be very considerable, and that there will be little guarantee that the projectiles supplied are of the proper quality.

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In regard to the three first objections—a careful examination into the details of construction would, I am convinced, satisfy any unprejudiced and reasonable mind that the objections are groundless; in fact, that in these particulars the Diaphragm Shrapnel Shell will bear comparison with any other article used for warlike purposes; and the following results, which have been obtained in prosecuting the enquiry into the various points connected with the manufacture, indicate a degree of perfection which could hardly have been anticipated.

1st.—A number of shells taken indiscriminately from those which had been prepared to receive the bullets, were tested with mercury, and with spirits and water, to see whether a complete separation was effected by the diaphragm and socket; and it was found that, in every instance, both the mercury, and spirits and water, were retained in the powder chamber, and that there was not the slightest leakage in any part.

2nd—A number of shells prepared for service, were arranged in a strong box, in a way to allow them a certain play; the box was placed upon the sand shifting machine* of the Foundry, and the machine was worked for 10 hours every day for 12 days, at the end of which time the shells were examined, and found perfect.

3rd.—Six shells prepared as for service, but with the top of the socket flush with the exterior of the shell, were worked for 4 hours, with a large quantity of other natures of shells, in the shot and shell cleaning Machine,† after which, upon examination, they were found perfect. No amount of jolting, similar to that which shells are subjected to in travelling,

* The machine consists of a tray or sieve attached to an eccentric, which, upon revolving, moves the tray backwards and forwards with considerable velocity, thereby violently shaking its contents.

† The Machine consists of a large iron cylinder, above 10 feet in Diameter, into which the shot and shell are placed, to be cleaned from the sand, &c., after they are cast. The cylinder, as it revolves, keeps the balls continually rolling, one over the other, and against the sides of the machine.

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could have so great a destructive effect, or any thing approaching to it, upon the projectile, as the action to which these Diaphragm shells were subjected.

4th.—A number of Diaphragm Shells, loaded with the bursting powder, &c., were sunk in the Canal, and allowed to remain under water for one week, after which they were examined, when the contents were found quite dry.

As to the last named objection, I have only to say that our experience is entirely at variance with this notion—in fact, we find far less difficulty in manufacturing the Diaphragm Shell than the ordinary 32-pounder Round Shot, and there is less skill and care required to insure a proper quality in the former, than in the latter;—this is no matter of opinion, but a fact. I may mention, however, that this success in the manufacture of the shell, has only been attained by the very complete system which has been adopted.

As to the expense of casting—the additional cost consequent upon the peculiar construction of the diaphragm pattern is, upon an average, 5 shillings upon one hundred shells.

In my Memo. (see appendix), I pointed out the great—I may say—fatal defect, which existed in the old Shrapnel, as well as the cause; and I drew attention to the varied results which have been obtained, in practice, with this missile. However, I am aware that doubts are still entertained by some in regard to these points.

Now, it may safely be affirmed, that there are no facts in relation to artillery matters which have been more completely established by actual experiment than these, namely,—Firstly. That the original shrapnel shell could not be depended upon in regard to its withstanding the shock from the explosion in the gun, even when reduced charges were employed; and, secondly, that this defect was almost entirely due to the arrangement of the powder and bullets.

It must be admitted—certainly by every military man—that

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the absence of uniformity of action in "war materiel" constitutes a very serious defect; and, in regard to the shrapnel shell, that if there exist great uncertainty as to whether or not it will burst "prematurely", or in the gun, then it is a question whether such a missile might not, with advantage, make way for a round shot in the ammunition boxes; for a failure of this nature does not merely involve the loss of the effect of a shell, but is a bar to its employment in the field, under a great variety of circumstances.

I have stated that the results of the experiments with Shrapnel Shells of the original construction, namely, with the "lip" or interior projection of the fuze-hole, carried on at Shoebury Ness in 1852, were comparatively satisfactory; but that in 1853, the very same description of Shells, fired as far as could be ascertained under precisely similar circumstances as in 1852, failed most completely.

As the greatest possible care was taken with these shells in regard to their manufacture—to the removal of every portion of grit from the interior—and to fuze holes and fuzes—these particular experiments may be taken as a fair illustration of the merits of General SHRAPNEL's most approved arrangements.

Similar trials to those carried on in 1849 with the larger calibres, were made with the 9-pounder gun, and 24-pounder howitzer, in 1853, for the purpose of discovering the true cause of failure; and surely the results which are recorded below are sufficient to prove, beyond the shadow of a doubt, what was the real defect of General SHRAPNEL's arrangement.

FIRED IN 1852.

Date.	Nature of Gun.	Number Fired.	Premature Explosions.	Remarks.
8th & 9th October.	24-Pr. Howitzer	49	0	With Bursting Powder.
7th October.........	9-Pr. Gun......	25	0	
Total...	....	74	0	

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Fired in 1853.

Date.	Nature of Gun.	Number Fired.	Premature Explosions.	Remarks.
1st July............	9-Pr. Gun......	49	26	
12th August........	„	50	4	
19th August.	„	10	1	
9th September ...	„	10	5	
14th October	„	10	2	
19th October	„	45	0	
Total...	....	174	38	With Bursting Powder.
13th August........	24-Pr. Howitzer	50	25	
19th August........	„	20	8	
9th September ...	„	5	4	
14th October	„	10	5	
19th October	„	40	5	
Total...	....	125	47	

Fired in 1853.

Date.	Nature of Gun.	Number Fired.	Number broke.	Remarks.
16th August........	9-Pr. Gun......	10	0	
9th September....	„	10	0	
21st September....	„	20	0	
Total...	....	40	0	Without Bursting Powder.
16th August........	24-Pr. Howitzer	10	0	
19th August........	„	10	0	
9th September....	„	5	0	
21st September....	„	20	0	
Total...	....	45	0	

Fired in 1853

WITHOUT BURSTING POWDER, TO ASCERTAIN WHETHEB THE FUZE IS DRIVEN OUT BY THE REACTION OF THE BULLETS,

Date.	Nature of Gun.	Number Fired.	Number found with plugs.	Number found without plugs.
21st September....	9-Pr. Gun......	20	20	0
21st September....	24-Pr. Howitzer	20	20	0
Total...	....	40	40	0

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With the smaller calibres of guns, namely—the 6-pounder and 9-pounder, the percentage of failures from premature explosions is *generally* far below that obtained in the larger calibres, as might reasonably be expected, when the true cause of failure is considered.

There cannot be a question as to the vast importance of using the highest charges with Shrapnel Shells, *but, what would be the result if the full service charges for round shot were employed with Shrapnel Shells of the original construction, namely—8lbs. for the 24-pounder, 10lbs. for the 32-pounder, and 20 and 16lbs. for the 68-pounder? Why, recorded facts will shew, that almost every shell would burst in the gun.*

When we consider the violent action which takes place in the interior of the Shell, when discharged from the gun, together with the peculiar properties of gunpowder, one would hardly expect even partial success with the original arrangement.

If further proof than that afforded by the above, as well as by the experiments in 1849, as to the true cause of failure with the original Shrapnel Shells, be required, the results obtained with the Diaphragm pattern, contrasted with the practice with the old Shrapnel, must satisfy even the most sceptical upon this point, and demonstrate, in the most conclusive manner, the absolute necessity of a separation between the bullets and the bursting charge, in order to render the Shrapnel principle efficient; for, although, the Diaphragm Shell offers no greater resistance to fracture in the bore than the original Shrapnel Shell, (in fact I believe it is a weaker shell on account of the grooves), still, not a single premature explosion has occurred in all the *experiments* which have taken place with this missile, notwithstanding the severe proof to which they have been put, namely—that of firing them from the large calibres of guns with the *full service charge for round shot.*

From the heavy 68 Pdr: (112 cwt.) many shells have been

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fired successfully with charges of 20 lbs. of powder, whereas with the old Shrapnel, premature explosions sometimes occurred when only 6 lbs. charges were used; and again, from the 24-pounder the shock from an 8 lbs. charge has not been found too great for the Diaphragm pattern when properly manufactured—yet, a 2½ lbs. charge from a 24-pounder Howitzer, has very frequently destroyed the old shell in the bore of the gun.

When the merits of the old and the new systems are compared in respect to the premature explosions, it is necessary, in order to arrive at just conclusions, that the conditions of charge and calibre of gun be taken into account. It is not sufficient merely to count up all the premature explosions in experimental or ordinary practice with various calibres of guns and charges made over a certain period, and then to compare the results—only as to the percentage of failures—such a plan would give but a very imperfect idea of the value of the new system.

There is reason to believe that the Diaphragm shell, as now manufactured in the Laboratory, will even withstand charges equal, or nearly so, *to one half* the weight of the projectile, notwithstanding the increased effect produced by the charge, on account of the diminution of the windage which I have adopted in the experimental shells.

I have already fired 28 12-pounders with 5 lbs. charges, and 20 9-pounders with 3½ lbs. charges, without a single failure, although the metal in some of the shells was known to be of an inferior quality as to toughness.

With reference to this point, namely—the diminution of windage—perhaps it will be as well for me to say a few words.

In the first place, my endeavour has been to make, as far as practicable, a perfect Shrapnel shell, and in designing the experimental shells lately submitted for trial, every thing was done to further this object.

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When the "wood bottoms" were fixed to the shells metal straps, great inconvenience would have resulted loading, if the original windage had been diminished, *on count of the loosening of the straps which passed round projectile;* but now that the "bottoms" are attached means of rivets, a great reduction may be made without slightest inconvenience in relation to loading; and from Shrapnel shell being considerably lighter than the solid sho (the 9-pounder weighs, for instance, upon an average, 9 l 4 ounces with the wood bottom, whereas the new shell wei only 8 lbs.) the windage in the former may be considera reduced without increasing the strain upon the gun carriage, beyond that which results from firing solid s with the regular windage. In fact, the experiments, so as I have made them, give this result—that the recoil of t 9-pounder gun, when the high gauged shell is fired, is, an average, one-twelfth less than when the service solid sh is used; and in regard to the strain upon the howitzer ca riages, the recoil with the high gauge Diaphragm Shell slightly *less* than with the old Shrapnel Shell—this resu is due to the former shell being lighter than the origi Shrapnel, although it is slightly larger in diameter.

However, I have not considered it desirable, under prese circumstances, to increase the size of the projectile beyo *the diameter of the established gauge for "strapped shells"* but, I must observe that this alteration has nothing whatev to do with the *principle* of the shell, although, in itself, i has advantages:—for instance, in assimilating the practic of Solid Shot and Shrapnel Shells, *in regard to elevation* when the same charges are used;—this alone is a very important point gained.

In regard to the Diaphragm Shrapnel Shells which were supplied by contractors during the late war, and which I have stated to be defective in design and workmanship, I would say a few words; but, before doing so, I must ex-

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plain that the word *design* has reference merely to the *details*, and not to the *principle* of construction, as may be clearly seen from the opening paragraph of my Memo. of the 8th February.

If the circumstances under which these shells were designed and manufactured are duly considered, it must appear evident to any person who has had but a slight experience in such matters, that perfection could not have been reasonably expected.

It is well known to every Artilleryman, that, from the imperfect knowledge which is at present possessed in relation to the peculiar action generated at the explosion of gunpowder, complete success can seldom or never be attained when dealing with this subtance, without a most careful experimental investigation into all matters connected with the particular and desired object.

Now, with the shell in question, no sufficient investigation for the purpose of determining the arrangements to secure *complete* success, was made until within the last few months. In fact, the shells which were introduced into the service, after severe trials, are almost identical in the details of construction with those which were designed before I had had an opportunity of making a single experiment: the success, therefore, which was obtained in 1852 and 1853, is surprising, and affords sufficient proof as to the value and correctness of the *principle*.

With reference to defective workmanship:—The shells which were tried in 1852 and 1853, were made by the most experienced founders in the country, whereas those received into store during the late war, were principally supplied by manufacturers who had had no previous experience in casting military projectiles; therefore—although the best possible arrangements were adopted at the time, by the War Department, to insure an efficient supply—it is not unlikely that these particular shells will sometimes fail in practice.

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But the fact of a failure, of many failures, could not justify that wholesale condemnation which has been made of the principle of construction of the Diaphragm Shell. If so, then, with equal justice we might condemn the whole "artillery matériel," upon which we pride ourselves so much.

Had there not existed a positive necessity for a large supply of Shrapnel Shells in 1855, they would not have been obtained from firms who were not possessed of sufficient experience to insure the very best quality; as it was, the number contracted for was far below what was deemed necessary, at the time, to meet the wants of the service; and, moreover, it was, in order to secure to the service a due and efficient supply of military projectiles, that the Shot and Shell Foundry was established in the Royal Laboratory.

I will now point out what alterations it has been found necessary to make, after due investigation, in the details of the original construction.

1stly.—In the original design, the diaphragm or partition was fixed *into* the cast iron of the shell, as shown in Fig. 7. (Plate 49). It was found, however, from the resistance which was offered to the action of the bursting charge by the cast-iron projection below the diaphragm, that there was a great tendency to fracture through *AB*; and that, in order to cause the shell to open at all times in the way intended, an increase in the depths of the grooves was necessary: but, as this alteration in the grooves would have weakened the shell, and made it less capable of withstanding the shock of a heavy charge, it was thought more advantageous to remove, in part, the projections which caused the resistance of the diaphragm to the action of the bursting powder, as shown in Fig. 1 and Fig. 2.

The reason why these projections were not entirely removed is obvious—for the diaphragm not being acted upon directly by the charge, motion could only be communicated to it *through* the shell; and, therefore, unless there existed

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a support equivalent to the force required to give the same degree of motion to the diaphragm, as that acquired by the shell from the direct action of the charge, the diaphragm would be displaced by the shock of the explosion in the gun. I have found that, by removing about one-half of the support which the diaphragm had in the original design, most satisfactory results are obtained in regard to the fracture of the shell by the bursting charge, and at the same time sufficient support is left to prevent the diaphragm from being displaced, even when very high charges are used. The extraordinary regularity in the size and form of the splinters of the shells lately fired, as well as the unerring precision with with the bullets proceeded after they were relieved, proves the efficiency of this arrangement.

2ndly.—In designing the smaller natures of shells in 1853, the construction of the 24-pounder was taken as the basis, and the thickness of metal at the fuze holes in the 12-pounder, 9-pounder, and 6-pounder, was made nearly proportionably to the different calibres. But the socket into which the fuze is fixed being of the same dimensions and *weight* in all natures of shells, the thickness of metal at the fuze-hole, which has to support the socket when the shell receives the shock from the explosion of the charge, ought not to have been fixed in this way; and, I found that, when very large charges were used, the socket in the smaller natures of shells was at times displaced, and partially driven inwards, thereby cracking the metal at the fuze-hole. In the present construction, I have remedied this defect by increasing the thickness of metal where the socket is screwed in.

3rdly.—In the improved design for larger calibres of shells, the metal has been made thicker at the bottom, or at that part which is next the charge when the shell is in the gun, than in other parts; for I found by careful experiment that, with the original thickness, and when the metal was not up to the proper standard in quality, there was a liability

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to fracture at the bottom part of the shell by the direct action of the charge in the gun; and, in fact, that this was the weak point of the projectile.

4thly.—In the experimental shells, the whole of the interior surface has been coated with marine glue, as is done in Lancaster's shells, in order to secure a perfect separation between the bursting powder and the bullets, and to prevent deterioration from rust. The same might be done with the shells in store, and with very great advantage.

In the latter paragraph of my Memo. upon Shrapnel Shells, which was dated the 8th February, I observe—" and I have " every reason to believe that the object for which I have so " earnestly striven, will be attained, namely—to supply the " service with a Shrapnel Shell possessing all the valuable " properties of the original invention, without its serious de- " fects." Since this was written, extensive experiments have been carried on with the Diaphragm Shell, both of the ordinary and of the increased diameter; and the success which has been attained in these trials, has exceeded my most sanguine expectations, particularly as regards the uniformity of action.

It has been proved most conclusively that not only has that fatal defect which existed in the original Shrapnel, namely—liability to premature explosion—been completely overcome in the diaphragm pattern, but that in every other respect the projectile is all that can be desired in the Shrapnel system.

Tables 1 and 2 shows the result of 60 12-pounder, 60 9-pounder, and 60 6-pounder experimental Diaphragm Shrapnel Shells, fired at ranges varying from 1,200 yards to 650 yards. The 9-pounders and 6-pounders were of the increased diameter, but the 12-pounders, owing to a mistake, were made of the original size, and therefore had a windage of upwards of two-tenths of an inch. The results were carefully recorded under the direction of Captain ORR, the Captain Instructor of the Royal Laboratory. These shells were fired,

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in one important respect, under unfavorable circumstances, for the most suitable elevations and lengths of fuze were not previously determined.

I am aware that various opinions are entertained by artillery officers in relation to the value of Shrapnel shells as a military projectile; and, although it is not my intention in this paper to discuss the merits of this most destructive missile, I cannot refrain from making a few remarks upon what appears to me to be an extraordinary notion which has lately been advanced in relation to this point, namely—that a round shot is, under all circumstances, a more efficient projectile than a Shrapnel shell, and that the latter ought to be removed from the field service.

Let us consider for a moment what this opinion involves; no less than this—that Round Shot are more efficient than Case and Grape at very short ranges. But, in fact, there are even stronger reasons why Shrapnel should be more destructive than Round Shot at long ranges, than that Case and Grape should be superior to Round Shot at short ranges, when the irregularity in range of Round Shot, combined with the effect produced in the direction of their motion by grazing on irregular ground, are duly considered.

Even on the sands at Shoebury Ness, and more frequently on the Marshes at Woolwich, a round shot will, after striking the ground, often ricochet at a considerable elevation, and pass over many hundred yards before it again touches the plane, and also be deflected considerably to the right or left of the object aimed at; and if the practice were carried on over the ordinary ground of any country, which was the seat of war, this irregularity would be greatly augmented.

But, at short ranges, as the shot would seldom or never strike the ground until after it had taken effect upon the object fired at, there would be no injurious effect of irregularity in its action from grazing; and, consequently, there is, as I have stated above, greater reason why a Shrapnel should,

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under a great variety of circumstances, be a more efficient missile in the field than a round shot at a long range, than that Grape and Case should be superior to Round Shot at a short range.

There is one thing, however, in connection with this point which must not be overlooked, namely—that with Shrapnel the fuze has to be regulated for a particular range, which is not the case with Grape and Case. But, according to the present system, the operation of preparing the shell is of that simple character, that any man could, with proper instruction, be made thoroughly expert in a very short time, as compared with that which it is considered necessary to devote to far less important matters; *and, moreover, the rapidity with which this operation can be performed, with properly instructed men, is so great, that Shells may be fired successfully as quickly as round shot, if it be considered desirable to do so.*

There is a point of much importance, which has been well established by the results of the experiments lately carried on with Diaphragm Shells at Woolwich, namely—that if the *elevation* be correct, it matters little whether the shell burst at 100 yards, or 20 yards, from the object fired at, so that, when the corresponding lengths of fuze and elevations have been determined upon by experiment, the practice with Shrapnel will become very simple.

It is not to be wondered at that objections were raised to the Diaphragm shell when first proposed, for every novelty in war matériel ought to be examined in the most critical and complete manner; nor need there be much surprize that objections were continued after it was introduced into the service—as with every thing new, prejudice, as well as deficient information, has to be allowed for. When failures take place, erroneous conclusions are not unfrequently drawn from the want of an exact and systematic arrangament of the facts connected with the trials. It is, however, a matter of

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surprize that after the recorded experience which was obtained in the late war with Russia, there should be found objectors to the present system of fuze; and when it is stated that the system is a tedious one, I am obliged to answer the defect complained of does not arise, as can be readily proved, from any imperfection in the system, but must result from the want of proper management in its application.

It is unreasonable to expect to find any man, unaccustomed to the use of mechanical tools, who shall be able, without proper instruction, to perform the operation of preparing a fuze sufficiently quickly. We do not expect an Artilleryman to be able to lay a gun correctly, to estimate even short distances, or even to execute correctly the simplest matter of position or drill, unless he has been thoroughly taught on these points.

I find from experience that a company of Artillery may, under proper instruction, be made thoroughly expert in the management of fuzes and shell in ten hours, and that as regards the time occupied in the operation, it requires but ten seconds, on the average, to prepare the fuze and fix it in the shell. Surely a period of ten hours bears but a small proportion to that during which it is supposed necessary to detain an artilleryman under instruction, even in matters not strictly belonging to his efficiency as such.

Had it not been for the simplicity and accuracy of the system of shells and fuzes, it could not possibly have met with that universal approbation which it received from those engaged in the Crimea and the Baltic; for, owing to these fuzes not having been issued for practice previous to the breaking out of the war, the men were but little instructed in their use; and, consequently, such complete success as that which was obtained, could scarcely have been anticipated. If the present system of fuze, and that which was previously in operation, and which was, to a certain extent, tried during the late war, be compared, and the effect pro-

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duced by the change be considered, the acknowledgment can hardly be refused, that, to say the least of it, an important improvement has been effected, and that in spite of the obstructions and difficulties, friendly and unfriendly, that I have met with in my endeavours to perfect the Shrapnel shell, there has resulted a series of practice which has never been surpassed (or indeed approached) by any missile hitherto employed in the service of artillery.

I commend these few observations to the consideration of my brother officers, in the confident expectation that they will not be led away by vague statements and opinions, but will accurately examine for themselves, both the result of experiments, and *into* the system and precautions used in the manufacture of this important war materiel; in which case I need hardly say that their criticism will be of the utmost value, as their judgment will be considerate and reasonable.

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ING RANGES VIZ:

TOTAL. Distance from No. 1 to No. 8. 135 yards.										
Targets 80 feet by 8 feet.									Total.	Penetration.
2 inch Brds.	One inch boards.									
1	1	2	3	4	5	6	7	8		
845	530	1079	704	699	743	894	464	341	6308	Through
3	....	....	....	....	....	....	....	1	4	·2
8	21	49	42	17	21	28	15	9	210	·3
7	9	17	23	8	13	15	8	6	106	·4
21	10	21	18	19	22	20	9	11	151	·5
46	23	59	42	41	17	58	21	21	328	·6
37	12	24	19	23	24	23	21	20	203	·7
28	5	15	9	18	8	12	3	2	100	·8
24	2	5	8	2	....	1	1	....	43	·9
47	....	....	....	....	....	....	....	....	47	1·0
26	....	....	....	....	....	....	....	....	26	1·1
62	....	....	....	....	....	....	....	....	62	1·2
42	....	....	....	....	....	....	....	....	42	1·3
31	....	....	....	....	....	....	....	....	31	1·4
34	....	....	....	....	....	....	....	....	34	1·5
47	....	....	....	....	....	....	....	....	47	1·6
14	....	....	....	....	....	....	....	....	14	1·7
14	....	....	....	....	....	....	....	....	14	1·8
3	....	....	....	....	....	....	....	....	3	1·9
5	20	55	17	33	16	39	51	40	276	·0
13	45	84	53	46	60	51	29	37	418	·05
20	29	94	49	46	52	60	50	55	455	·1
1	....	....	....	....	8	4	3	2	18	·15
28	24	69	45	28	38	39	23	39	333	·2
1	....	1	....	....	....	2	1	1	6	·25
15	5	12	6	7	12	9	4	6	76	·3
854	530	1079	704	699	743	894	464	341	6308	Through
494	82	190	161	128	105	157	78	70	1465	Lodged
123	83	315	170	160	186	204	161	180	1582	Struck
1431	735	1584	1035	987	1034	1255	703	591	9355	Total.

umber of Bullets in the 180 Shells.......... 9,600

) No. 66, one board and a piece of another deficient.

A. ORR, Captain R. A.,
and Captain Instructor, Royal Laboratory.

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om

Brds.	
6	
8	
20	
23	
25	1
19	
10	
1	
12	
10	
12	
30	
19	
21	8

toa

and

...om 12, 9, and 6-pounder

TOTAL. Distance from No. 1 to No. 8. 135 yards.									
Targets 80 feet by 8 feet.									Total.
Brds.	One inch boards.								
1	1	2	3	4	5	6	7	8	
6	2	7	4	3	4	....	....	....	26
8	6	18	6	3	3	5	2	1	52
20	7	15	17	11	7	5	6	2	90
23	9	27	10	16	7	7	5	....	104
..	1	2	1	1	1	1	....	....	7
25	14	26	27	15	10	10	3	4	134
19	7	11	8	8	7	5	6	4	75
10	2	11	8	9	1	10	4	3	58
..	6	6	2	1	1	1	1	3	21
1	4	2	2	2	1	2	....	....	14
..	1	....	....	....	1	2	....	....	4
..	....	....	....	1	2	....	....	....	3
..	....	....	....	1	....	....	....	....	1
12	59	125	85	71	45	48	27	17	589
10	5	15	16	12	8	8	2	....	76
22	64	140	101	83	53	56	29	17	665
30	3	6	5	8	3	4	1	....	60
39	17	45	43	35	34	32	21	16	312
21	84	191	149	126	90	92	51	33	1037

...e board and a piece of another deficient.

A. ORR, Captain R. A.,
...and Captain Instructor, Royal Laboratory.

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APPENDIX.

MEMORANDUM.

ON

Shrapnel Shells.

8th February 1858,

Certain opinions in condemnation of the *principle of construction* of the Diaphragm Shell having been widely circulated—which opinions have been formed upon most imperfect data—the following observations are drawn up with a view to afford such information as may place this matter in its proper light, and to remove the false impressions which now exist in respect to the subject generally,—and I am sure that a careful consideration of recorded facts, and of the explanation which I shall afford, will show, that the Shrapnel Shell, as arranged by the inventor, has defects of a very serious character; and that if the principles which have guided me in constructing the Diaphragm Shell are properly carried out, every defect will be rectified, and the service with this nature of projectile will be rendered capable of a development considered hitherto impracticable.

In the early part of 1849, I first became aware of the unsatisfactory results which were obtained in the practice with Shrapnel Shells, from very frequent "premature explosions;" and for the purpose of overcoming the defect, I designed a Fuze similar in the principle of its construction to that now adopted in the service for horizontal shell firing.

My views upon this subject having been brought to the notice of the Master-General of the Ordnance, were referred by him to the Ordnance Select Committee, who recommended that a series of trials should be made in order to determine the true cause of failure.

These experiments took place in the Marshes at Woolwich in 1849, and the results proved beyond doubt (at least to my

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mind) that the failures resulted in a great measure from the bursting charge being mixed with the bullets, and that no alteration of the fuze would altogether prevent premature explosions,

The general opinion then entertained in regard to this matter was, that the shell was not sufficiently strong to withstand the "shock of the discharge," in fact, that the shell was broken by the direct action of the charge in the gun.

This opinion was found to be fallacious by the following experiment, which also manifested the principal defect of General Shrapnel's arrangement.

8 inch, 32 pounder and 24 pounder Shrapnel Shells carefully selected were prepared as follows, and fired with charges of 10 lbs, 10 lbs. and 8 lbs. respectively.

1. Filled with bullets and *the bursting powder*, and with a solid plug of wood firmly driven into the fuze-hole.

2. Filled with bullets, but *without the bursting powder*, and with a solid plug of wood firmly driven into the fuze-hole.

Nearly the whole of the shells with the bursting powder exploded in the gun, but there was not ONE *breakage with the shells* WITHOUT THE BURSTING POWDER.

The same descriptions of shells were then fired with a reduction of 2 lbs. in the charges, with similar results.

I noticed in these trials that some of the shells *with bursting powder* which were not destroyed in the gun, burst upon striking the butt, although there was no fuze in the shell.

These results led me to the following conclusions:

1st. That with the most perfect fuze premature explosions would occur.

2dly. That the shell was strong enough, if properly made, to withstand the direct action of the charge; and.

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3rdly. That by the shock which the projectile received at the "discharge," sufficient heat was evolved in some *part* of the interior of the shell, by friction or condensation, to ignite the bursting powder.

In order to diminish the effect from friction, I suggested that the interior of the shell should be coated with a cement. Some shells so prepared were fired, but with most unsatisfactory results; in fact, if I recollect rightly, there were more failures with the coated, than with the ordinary shells.

I then proposed the principle of separating the bursting charge from the bullets, as the *only* means of *securing* success. Some shells arranged according to this principle were fired, and the results of the trial were very satisfactory.

The Select Committee did not then agree with me as to the necessity of separating the powder from the bullets, and proposed, after a very limited trial, to remedy the defect by reducing, very considerably, the charges of the guns.

This proposal I felt sure would, if carried into effect, only lead to disappointment; for, besides seriously diminishing the effect of the projectiles as regards the velocity of the bullets, premature explosions would still take place, although not perhaps to the same extent as before.

If it were necessary to raise the whole of the bursting powder, or any large portion of it, to a certain temperature to cause ignition, then by limiting the charge, failures from premature explosion might be entirely prevented. But when, as is the case, the ignition of one grain, or portion of a grain, is sufficient to explode the whole charge, it is clear that no positive security against failure can result by reducing the charge in the gun when the bullets are mixed with the powder.

The recommendations of the Select Committee, as stated above, were adopted, and the charges for the 8 inch, 32-pounder, and 24-pounder, were fixed at 6 lbs., and 5 lbs, respectively.

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As the suggestion of separating the powder from the bullets was not entertained, I proposed that all Shrapnel Shells should be constructed according to the inventor's original pattern, namely, with a "lip," by which arrangement the bullets could be packed firmly in the shell, and thus cause a diminution in the action tending to ignite the bursting powder.

A number of shells so constructed were fired at Shoebury Ness in 1852, and the results were satisfactory;—the same pattern however failed most completely in 1853, and altogether the practice both at Shoebury Ness and elsewhere most fully confirmed my views in respect to the effect of reducing the charge of the larger nature of guns.

Similar experiments to those carried on at Woolwich in 1849, and which I have already noticed, were made at Shoebury Ness; and so striking were the results that even the most sceptical were forced to acknowledge that to render the Shrapnel Shell an efficient projectile, a separation of the bullets from the powder was necessary.

In the trials made in 1849, the fuze-holes were secured with solid wooden plugs, and it was imagined by some that these wooden plugs had been forced out when the shells were in the gun, by the reaction of the bullets, and that the flame from the explosion of the charge was communicated to the bursting powder through the fuze-hole. This hypothesis was put to the test of experiment:—Fourteen 24-pounder Shrapnel shells were carefully selected, the fuze-holes tapped with a screw, and the shell thoroughly cleaned. Eight were filled with bullets closely packed, and with the bursting charge, viz., 6 ozs of powder, and the remaining six with bullets, but *without* the bursting powder. The fuze-holes of the whole were perfectly secured by *screwing* in gun-metal plugs. These shells were fired at Shoebury Ness on the 7th to 11th of October, 1853, from a 24-pounder Howitzer, with charges of 2½ lbs., when *six out of the eight shells*

which contained bursting powder burst in the bore of the howitzer, but the six without the bursting powder were uninjured.

In the very extensive experimental and other practice with Shrapnel shells of the original construction which I have had an opportunity of witnessing since 1849, I have particularly noticed the varied character of the results. At times few, if any, premature explosions occurred; and at other times almost every shell that was fired burst in the gun, although the conditions appeared to be precisely the same; and I observed also that with the 24-pounder Howitzer, with the small charge of $2\frac{1}{2}$ lbs., the failures were generally far more frequent than with other field guns.

Although the suggestion of separating the bursting powder from the bullets was rejected by the Select Committee in 1849, I felt sure from the experiments which I had witnessed, that sooner or later this principle would be adopted; and I only waited for a favourable opportunity to renew my proposal.

This occurred in 1852—the date I am not certain of—when some experiments were made in the Marshes with Field Artillery, and the Minie rifle, in which the extremely unsatisfactory condition of Shrapnel shells was plainly manifested; and I immediately brought the subject to the notice of the Master-General, and proposed the Diaphragm pattern. In designing the Diaphragm Shrapnel Shell, an endeavour was made to fulfil the following conditions:

1st. That the shell shall resist the shock from the explosion of the full service charge; and

2nd. That the bullets when relieved shall be but slightly affected in the direction of motion of the shell, by the action of the bursting powder.

In regard to the first point—as the velocity of the bullets must be considerable to render them effective—and this

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velocity being derived from the action of the charge in the gun—any reduction in the charge must cause a corresponding reduction in the effective range; hence the advantage of firing Shrapnel shells with the full service charge; but whatever charge is used, there ought to be great security that no premature explosions shall occur, or this description of projectile could not be used with advantage under a great variety of circumstances, which must constantly occur in warfare—particularly now, when, from the great perfection in the rifle, skirmishers will be employed so much more extensively than heretofore,

With reference to the second condition, namely, that the bullets when relieved shall be but slightly affected in the direction of motion of the shell by the action of the bursting charge.—From the great difficulty of correctly judging the distance of an object, or even where a shell bursts in respect to an object, the real efficiency of the Shrapnel Shell will be much affected by any great dispersion of bullets from the action of the bursting powder; in fact it is a matter of great importance to limit the divergence of the bullets from the trajectory of the shell to such an extent, as to make it a matter of little consequence whether the shell burst 50 or 100 yards from the object fired at.

A separation of the bullets from the bursting powder being absolutely necessary to fulfil the first condition, it became a question as to the best mode of carrying out the principle. My first idea was to arrange the shell according to the plan which I afterwards adopted to overcome the defect of premature explosions in the old Shrapnel Shells; but I soon perceived that the arrangement, although simple, would not fulfil the second condition; for in the first place, the action of the bursting powder must be sufficiently great to break the shell into comparatively small pieces in order to separate the bullets; and in the second place, the whole force from the explosion of the bursting powder acting from the centre

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of the mass in an outward direction, would thereby cause great dispersion in the bullets.

These considerations induced me to seek for some more efficient plan, and to adopt the arrangements carried out in the Diaphragm pattern.

The peculiar features of the Diaphragm Shrapnel Shell consist,—in the separation of the interior of the shell into two parts by a wrought iron partition or diaphragm—and in the metal of the shell being so disposed as to cause the bursting powder to open the shell in a manner to relieve the bullets, without causing irregular dispersion from the trajectory of the projectile.

The accompanying drawing, (Plate 49) figures 1 and 2, represent sections of the Diaphragm Shrapnel Shell, Fig. 1 is made by a plane which contains the axis of the fuze-hole and Fig. 2 by a plane at right angles to this axis.

The bursting powder which is contained in the chamber (*p* fig. 1), being in advance of the bullets, and entirely separated from them by the wrought iron partition (*d*), is not affected by the shock received from the explosion of the charge in any greater degree than the bursting powder of a common shell—this arrangement, therefore, entirely remedies the defect fouud to exist in the original construction, in reference to the ignition of the bursting charge by the action of the bullets,—and it only remains to regulate the thickness, or rather strength, of the shell to resist the direct action of the force of the charge, in order to obtain security against premature explosions.

It appears from the result of many experiments, that the thickness of metal adopted by General Shrapnel, is all that is necessary to secure the above result, even when the shells are projected with very high charges, provided the material be of a strong and tough character, and that there be an absence of flaws. This thickness of metal has therefore been taken as the basis of construction in the Diaphragm pattern.

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The next point to be considered, and it is one of great importance, is that which refers to the action of the bursting powder. It is quite evident, that unless some provisions were made to regulate the effect of the bursting powder, the principle of General Shrapnel would be, to a great extent, sacrificed—in fact, the explosion of the bursting powder would separate the shell at the part (A B fig. 1) where the wrought iron partition joins the interior surface, and the bullets would either not be relieved from the shell, or would be affected more or less in their proper course, according to the relative positions of the powder and bullets at the moment of explosion, and the force of the explosion itself.—A special arrangement, has, however been made, which completely meets the difficulty; it is as follows:

1st, In order to prevent fracture where the diaphragm joins the interior surface of the shell, the resistance to fracture is made considerably greater through A. B. that at any other part of the shell, as shown in Fig. 1: and 2dly. Four grooves (g, g,′ g,″ g,‴ Fig. 2) and (g, g,′ Fig. 1), are made in the interior, extending from the fuze-hole to points near the bottom of the shell, forming so many lines of "least resistance," by which arrangement, in connection with that in relation to the general distribution of metal, the shell is opened in the way represented in Fig. 3, (taken by the camera from a shell burst with the regular bursting charge) and the bullets are affected but in a very slight degree, in their direction of motion, or dispersion by the action of the bursting charge.

The following objections have been urged against the principle upon which the Diaphragm Shell is constructed:

1st. That the projectile being "excentric," from the relative positions of the bullets and powder, great irregularity in flight must result.

2dly. That owing to the powder being on one side of the

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bullets, their velocity and proper direction of motion are considerably affected,

3rdly. That a complete separation of the powder and bullets cannot be secured.

In regard to the first point—although the projectile be "excentric," yet, as the *centres of force and gravity* are in a straight line which also represents the *direction* of the force produced by the ignition of the charge, no rotation will be generated in the projectile, and consequently no deflection will result from the peculiar arrangement of the mass.

The above objection was made to the Diaphragm Shell when it was first proposed; and in the experiments which were carried on at Shoebury Ness, particular attention was directed to this point, and it appears from the reports that the flight of the projectile was very regular.

As to the second objection—the explanation already given, is sufficient to show that the principle of construction is not defective in this particular; in fact, that if the design be efficiently carried out, thg peculiar arrangement in regard to the bursting powder and bullets, will act beneficially in every respect to the motion of the bullets when relieved from the shell;—but even if the desired object be not attained, as to the fracture of the shell, owing to imperfection in the manufacture or other causes, and the force of the bursting charge acts in an opposite direction to the motion of the projectile—it is clear from the very small quantity of powder in the bursting charge, and from the extremely short time during which the force can act, that the velocity of the bullets will be but slightly affected—and a simple experiment will show this to be the case.

In reference to the third objection—namely, that a complete separation of the powder and bullets cannot be secured—I have only to observe, that with a proper system no diffi-

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culty whatever is experienced in this matter, or in any other particular in relation to the manufacture of the projectile.

I am quite aware that the Diaphragm Shells in store are defective; but I must observe at the same time, that when the urgent demands for these shells were made, all was done that could be done, under the circumstances, to meet the wants of the service.

When the Diaphragm pattern was first proposed, I had no opportunity of making the necessary experiments, to determine various details in regard to the arrangement of the wrought iron partition, the depth of the grooves, &c., &c.; which, although in appearance but trifling, are nevertheless points upon which the success of the principle depends. However, as the results of the first trials at Shoebury Ness in 1852 and 1853 were reported as highly satisfactory, and there was neither time nor opportunity to prosecute the inquiries in relation to the *most efficient* arrangement—at a period when the shells were required for immediate service—the original design was adhered to.

The shells in question were supplied by contractors, the majority of whom were totally inexperienced; and owing to the peculiarity of construction, it was impossible when the shells were delivered, to test or examine them in a way to determine whether or not the design had been correctly carried out: these circumstances alone are sufficient to account for the condition of many of the shells now in store: but although I am prepared to admit that, owing to the above causes, the Diaphragm Shells which have been issued for service are defective—both in design and workmanship—I believe it will be fonnd on trial that the effect of these shells is nevertheless very destructive.

It only remains for me to state, that during the past few months I have pursued the enquiry in regard both to the design and manufacture, with most satisfactory results; and

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I have every reason to believe the object for which I have so earnestly striven, will be attained—namely, to supply the service with a Shrapnel Shell possessing all the valuable properties of the original invention, without its serious defects.

E. M. Boxer *Capt.* R. A.
Superintendent
Royal Laboratories.

Examples for the ready solution of the various problems that may present themselves in Decimal Fractions:—communicated by Captain G. Carleton, Adjutant Horse Brigade Madras Artillery.

DECIMALS.

1st. Divide 12 by ·7854:—here first of all, annex to the dividend four cyphers with decimal point prefixed, so as to equalize decimal places in both dividend and divisor; then proceed as in whole numbers, and after the quotient figure that exhausts the equal number of dividend decimals (in this case 5 which exhausts the 4th dividend decimal) place the decimal point thus:—

```
·7854) 12·0000 (15·2 &c.
        7 854:
        ------
        4 1460
        3 9270
        ------
         21900
         15708
         -----
```

2nd. Divide 123·70536 by 54·25:—here again equalize decimal places in both divisor and dividend, by annexing 3 cyphers to divisor; then after the quotient figure that exhausts the equal number of decimals in both divisor and dividend place the decimal point thus:—

```
54·25000) 123·70536 (2·2802
          108 50000
          ---------
           15 205360
           10 850000
           ---------
            4 3553600
            4 3400000
            ---------
              1536000
              -------
```

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or in this case we may as easily divide as in whole numbers without annexing cyphers to the divisor, and after bringing down the 6, point off in quotient as many figures for decimals as the decimal places in the dividend exceed those in divisor; and this plan has fewer figures in the body of the work thus:—

```
54·25 ) 123·70536 (2·2802
        108 50
        ------
         15 205
         10 850
         ------
          4 3553
          4 3400
          ------
            15360
            10850
            -----
```

3rd. Divide ·8297592 by ·153:—here simply count how many places of decimals the dividend exceeds the divisor by (viz. four) and mark off four decimals in the quotient.

Ans. 5·4232

4th. Divide ·06314 by · 007241

Before commencing the division, annex a cypher to the dividend to equalize the decimals in both; then divide and apply the ordinary rule for fixing decimal point in quotient, viz., *after* the figure in the quotient that exhausts the even number of decimals thus:—

```
·00|7241 ) ·0|63140 (8·719
             |57928
             ------
              52120
              50687
              -----
               14330
                7241
               -----
               70890
               -----
```

Cancelling the cyphers and proceeding as with whole numbers.

5th. Divide ·000|73) 65·17300 (89278·08

5 84

677
657

203
146

570
511

590
584

600 Cyphers brought down.

here we find counting all the cyphers brought down, we have 7 places of decimals in the dividend, and only five in the divisor, so the excess two is the number of decimals to be in quotient.

6th. Divide 343·67 into ·0048600:—here annex 5 cyphers to the divisor to equalize the number of decimal places in both, then rejecting the two left hand cyphers of dividend, commence the division as if in whole numbers thus:—

343·67,00000) ·00|4860000000 (0·000014141

3436700000

14233000000
13746800000

4862000000
3436700000

14253000000
13746800000

5062000000
3436700000

here the whole divisor goes into the dividend with an equal number of decimal places 0 times, so after that 0, place decimal point, then annexing beyond the even number of decimal places in dividend five cyphers, I at last find the divisor goes 1 into dividend; by this time if I count, Ifind the number of decimals in dividend is twelve and in divisor seven, so this 1 must be in the 5th place of decimals, therefore prefix to it four cyphers.

But in a case of this kind a shorter method would be at once to reject the cyphers in the dividend, and then commence

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the division as if we were dividing in whole numbers thus:—

```
343·67) ·00|48600 (14141
           |34367··
            142330. ··
            137468. ··
            ----------
             48620··
             34367··
             -------
             142530·
             137468·
             -------
              50620
```

now counting the number of cyphers brought down (4), and number of decimal places originally in dividend, I find there are eleven places of decimals in the dividend and only two in divisor, therefore as the sum of the decimals in divisor and quotient must equal their number in the dividend we must have nine places of decimals in the quotient; so prefixing four to the five there already we get ·000014141 Ans.

7th. Divide 17·32 into ·00056:—proceed as in whole numbers cutting off the left hand cyphers thus:—

```
17·32) ·000|5600 (3233
           |5196
            ----
            4040
            3464
            ----
             5760
             5196
             ----
              5640
```

we have now ten decimals altogether in dividend counting the cyphers (three) brought down, and there are but two in the divisor; so four cyphers must be prefixed to the quotient already found, so that the sum of decimals in quotient and divisor may equal the number of decimals in dividend, then we have ·00003233 as Ans.

The converse of the above is to divide ·00056 into 17·32:—here annex cyphers to the dividend until the decimals in it

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equal those in the divisor, then proceed to divide, rejecting the three left hand cyphers of divisor thus:—

```
·000|56) 17·32000    (30928·57
         16 8 ·····
         ------
           520 ····
           504 ····
           ----
            160 ···
            112 ···
            ---
             480 ··
             448 ··
             ---
              320 ·
              280 ·
              ---
              400
```

here then we have 7 decimals in the dividend including those brought down, while there are but five in the divisor; so mark off two figures as decimals in the quotient; for two in the quotient added to five in the divisor, will equal the number in the dividend; without going to so many figures it could be seen that the figure 8 in quotient, exhausts the even number of decimals in the divisor and dividend, so *after* it the decimal point *must* come.

8th.—Divide 186743.568 into 1432.56 :—here treat both as whole numbers, and add cyphers to the dividend to equalize its decimals with those in the divisor, then we have 186743·568) 1432·560 (0· into the dividend with its equal number of decimals the divisor goes 0 times; so after that 0 comes decimal point; or even disregarding that, let us go on dividing without determining the decimal point until the division is complete

```
then 186743·568) 1432·5600000000  (0·0076712
                 1307 204976 ····
                 ------------
                  125 3550240 ···
                  112 0461408 ···
                  -----------
                   13 30888320 ··
                   13 07204976 ··
                   -----------
                     236833440 ·
                     186744568 ·
                     ---------
                      &c. &c. &c. &c. &c.
```

here counting, we find the number of decimals in dividend which has been used, is 7 more than

those in the divisor; so counting from the right, mark off 7 places in the quotient as decimals.

9th.—Divide 240) ·26:—here the quotient figures must be all decimals; the easiest way to determine the fixing of the decimal point in such a case is, to annex at pleasure any number of cyphers to dividend

```
as 240) ·260000000 (·0010833
         240·····
         ——·····
          2000···
          1920···
          ———···
           800··
           720··
           ——
            800
            720
            ——
```

having got as far as the 2nd 3 of the quotient, we count and find the decimal places used are 7, and there being none in the divisor, it is necessary to prefix two cyphers to the quotient already found, and before all these put the decimal point; the sum of decimals then in the divisor (there being none) and quotient equals the number of decimals in dividend viz. 7.

Decimal Arithmetic Reduction.

Example 1.—How much is ·625 of a shilling.—Rule. Multiply the decimal, 1st by 12 as there are 12 pence in a Shilling; 2nd. by 2 as there are 2 half pence in a penny; and 3rd. if necessary, by 2 as there are 2 farthings in a half-penny; and after each multiplication, cut off as many figures from the right as there are decimals in the given decimal, thus:—

```
·625   Shilling.
  12   pence in 1 Shilling.
————
7·500
    2 half pence in one penny.
————
1000
```

the answer here then is $7\frac{1}{2}$d.

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Example 2.—How much is decimal ·009943 miles in yards, feet and inches?—here 1st multiplying by the number of yards in a mile, or 1760, and cutting off six figures from the right; 2nd. multiplying those 6 figures by 3, as there are 3 feet in 1 yard, and cutting off the same number of figures from the right; and, 3rd. multiplying by 12, as there are 12 inches in 1 foot, and cutting off figures as before, we get 17 yards, 1 foot, 5.98848 inches for answer.

The converse of the above is to bring a whole number or a decimal to an equal decimal of a higher name, as for example:—what is 9 pence as a decimal part of £1? here the rule is to divide by 12, as there are 12 pence in 1 Shilling, and 2nd. by 20, as there are 20 Shillings in £1 thus:—

```
12) 9d.
    ----
20) 0·75
    ------
  £ 0 0·375
```

or, as there are 240 pence in £1, say at once

```
                 £
240) 9·00  (0·0375
     7 20
     ----
     1 800
     1 680
     -----
      1200
      1200
      ----
```

Example 3.—What decimal is ·26 pence in terms of a pound sterling?

```
12) ·260000000
20)  ·21666666
   £·001083333
```

the decimals in 1st dividend exceed those in the divisor by 9 places; therefore, prefix two cyphers with decimal point in front, to make the number of decimals 9 in the last quotient.

Or, dividing at once by 240 the number of pence in a pound we get the same result.

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Example 4.—What is 24 yards in decimal parts of a mile?

$$\begin{array}{rll} & & \text{Mile.} \\ 1760 \text{ yards}) & 24{\cdot}000000 & (\cdot 013636 \\ & 17\,60 & \\ \hline & 6\,400 \text{ \&c. \&c.} & \end{array}$$

Circulating Decimals.

Example 1.—Required the equivalent vulgar fraction to decimal ·3333 &c.

$$\begin{array}{ll} \text{Let } x & = \cdot 3333, \text{ now} \times \text{by } 10 \\ \text{then } 10\,x \text{ will} & = 3{\cdot}3333\,; \text{ now Subtract} \\ \hline \text{and } 9\,x \text{ will} & = 3 \\ \text{that is, } x & = \frac{3}{9} = \frac{1}{3} \text{ Ans.} \end{array}$$

Note.—To multiply a decimal by 10, or 100, or 1000, merely move the decimal point as many places to the right as there are cyphers in the multiplier.

Example 2.—What is the equivalent vulgar fraction to ·9999 &c. &c. and to ·2525 &c. denoted by $\dot{9}$ and $\dot{2}\dot{5}$?

$$\begin{array}{ll} \text{Let } x \text{ here} & = \cdot 9999 \\ \text{then will } 10\,x \text{ be} & = 9{\cdot}9999 \quad \text{Subtract} \\ \hline \text{and } 9\,x \text{ will} & = 9 \quad \text{therefore } x = 1 \text{ Ans.} \end{array}$$

again, x suppose = to ·252525; multiply now by 100 for the ·25 the recurring part of the decimal.

$$\begin{array}{ll} \text{then we have } x \text{ as at first} & = \cdot 252525 \text{ Subtract} \\ \text{and } 100\,x & = 25{\cdot}252525 \text{ from} \\ \hline \text{and } 99\,x & = 25\cdot \\ \text{therefore } x & = \frac{25}{99} \text{ or } \cdot 252525 = \frac{25}{99} \quad \text{Ans.} \end{array}$$

these are the nearest approximate answers it will be understood, rather than the actual truth.

Example 3.—Find the fraction equal to ·16666 and ·7485353

$$\begin{aligned} \text{Let } x &= \cdot 16 \\ \text{then } 10\,x &= 1\cdot 6 \quad \text{Subtract} \\ \text{and } 100\,x &= 16\cdot 6 \quad \text{from, and we get} \\ 90\,x &= 15 \\ \text{and } x &= \tfrac{15}{90} = \tfrac{1}{6} \text{ or } \cdot 1666 \text{ \&c.} = \tfrac{1}{6} \end{aligned}$$

Again, let $x =$ ·7485353; now the unrecurring part ·748 is $= \frac{748}{1000}$ and if $x =$ ·7485353, $1000\,x$ must $= 748\cdot5353$, and also ·74853 is $= \frac{74853}{100000}$ or $100000\,x = 74853$

Now to get the recurring decimal of 2 places to the left of decimal point, we multiply by 100, then we have $100000\,x = 74853\cdot5353$;

$$\begin{aligned} \text{then from } 100\,000\,x &= 74853\cdot5353 \\ \text{Subtract } 1\,000\,x &= 748\cdot5354 \\ \hline 99\cdot000\,x &= 74105\cdot0000 \\ x &= \tfrac{74105}{99000} = \tfrac{14821}{19800} \end{aligned}$$

therefore, the vulgar fraction equivalent to ·7485353 &c. is $\frac{14821}{19800}$, both being equal to x.

Or, simply observe the unrecurring part of decimal, and put it in the form of a vulgar fraction, placing it as a numerator, and for its denominator put down units with as many cyphers annexed as there are figures in said numerator; then if x is = to the original, x multiplied by the denominator of the above vulgar fraction will be equal to the original decimal with its decimal point removed as many figures to the right as there are cyphers in said denominator; then if there be two recurring figures in the original decimal, multiply this last found value of x by 100 as above; if there be three recurring figures multiply it by 1000, and so on; and lastly subtract from this value of x, where there is a recurring period included, the value of x less the recurring period.

Note.—Every decimal is equal to a vulgar fraction, whose numerator is said decimal figures placed as whole numbers

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for a numerator, and whose denominator is as many cyphers with unity prefixed; thus, decimal ·25 is equal $\frac{25}{100}$.

(Signed) G. Carleton, Captain,
Adjutant Horse Artillery.

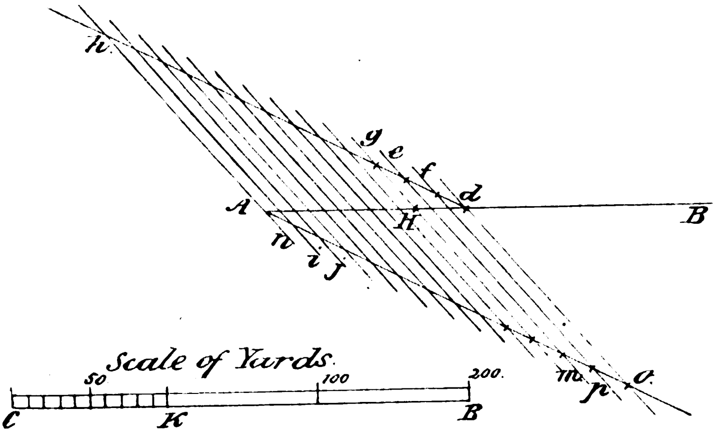
November 1858.

Easy directions for adjusting Scales in laying down plans on paper; communicated by Captain G. Carleton, Adjutant Horse Brigade, Madras Artillery.

For example; suppose a pieee of ground $1\frac{1}{2}$ miles long by $\frac{2}{3}$ of a mile broad has to be plotted, so as to be just contained within paper $21\frac{1}{2}$ inches long by $15\frac{1}{2}$ broad, what should the scale be?

1st Divide the length of ground by length of paper, or $1\frac{1}{2}$ miles=2640 yards by 21·5 inches which gives 122·8; so 122·8 yards to 1 inch must be the scale as far as length of paper is concerned; but the breadth also must be considered; $\frac{2}{3}$ of a mile is = $1173\frac{1}{3}$ yards which multiply by 3, to clear it of fractions, and we have 3520; having multiplied our width by, 3 the other, viz., that of paper must also be multiplied by the same; $15\frac{1}{2}$ multiplied by 3 gives $46\frac{1}{2}$, or 46·5; now divide the lesser width into the greater, that is $\frac{3520}{46.5}$ and we get 75·7 yds, to 1 inch as the scale for the breadth; but as it does not coincide with that for the length, this latter must be adopted, being the smaller of the two; so 122·8 yards to 1 inch is the scale required; but to allow a margin in the map and for greater convenience in working, a still smaller scale, as 125 or 130 yards to 1 inch would be better; should such a scale not be at hand it can be made thus on the margin of intended map or elsewhere; draw any line as *AB* and on it set off 1 inch very exactly as *Ad*, then set off any smaller distance from *d* along the line *dh*; as *df*, *fe*, *eg*, &c, thirteen times to *h*, and draw *AO*, parallel to *dh*, and set off from

A to *O* the same number of equal parts, as *An*, *ni*, *ij* &c. thirteen times, each equal to *df*; join *dO*, *fp*, *em*, &c. and these lines will divide *Ad*, into 13 qual parts as required.



Next draw any straight line as *CB*; on it set off *CK* equal to *AH*, or ten of the equal parts from *A* to *d*; then because the inch *Ad*, is divided into 13 equal parts, each part is equal to 10 yards, for we are making our scale 130 yards to 1 inch; but should it be reqnired to lay down a plan on a scale of 125 or 128 yards to 1 inch, the best way perhaps would be, to multiply these by 4, reject one figure to the right hand and then lay it down by the scale of 50; as 125 multiplied by 4 is 50|0; in the proposed plan the whole distance is 2640 yards, here multiplying by 4 we have 10560, rejecting the last figure we have 1056 to plot on a scale of 50 equal parts to 1 inch.

Now dividing this 1056 by 50 we get 21$\frac{1}{4}$ very nearly, which agrees very well with the length of proposed plan paper, and the 128 yards to 1 inch is so near to 125, that the latter may be used instead of it reducing it by 4 as above.

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The total length of ground to be plotted is as before stated 1½ miles or 7920 feet, the length of paper is 21½ or 21·5 inches, dividing which into 7920, as has been explained under the head "Decimals" we get 368·4; so the plan cannot be laid down on a larger scale than 368 feet to 1 inch; now if 368 be divided by 6 the quotient will be sufficiently near to 60 to allow (unless the paper be exceedingly limited) of the plan being plotted with the Marquois scale of 60, and all the distances measured in the field being divided by 6 may be laid down by the scale of 60 equal parts to 1 inch, or the Marquois Scale of 60; should it be desired to lay down the plan upon the scale of 50 the distance measured in the field must be divided by 7; thus suppose 7920 feet is to be laid down upon the scale of 50, divide by 7 and the quotient 1131 measured on the edge of the scale of 50 equal parts to 1 inch will be the distance to mark off on the plan.

(Signed) G. Carleton Captain,
Adjutant Horse Artillery.

December 17th, 1858.

Captain Norton's Liquid Fire Rifle Shell.

On February 10th, some experiments took place near the field-works of the Royal Engineers at Chatham, for the purpose of testing some new descriptions of missiles which have been invented by Captain J. Norton, an officer who has already made some valuable inventions in connection with the rifle. The afternoon was exceedingly wet and unfavourable for carrying on the operations but notwithstanding this drawback a number of officers of the Royal Engineers were present. The experiments first made were with a new description of rifle-shell, called, by Captain Norton, the liquid-fire rifle-shell. The object of this new missle is to set on fire the sails, rigging, and even the hull of any vessel against which the shell is thrown, and certainly the results of the experi-

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ments proved that the shell in question is one of the most extraordinary projectiles ever introduced into the art of warfare. The shell is about three or four times the size of an ordinary conical rifle bullet, but is hollow, the interior being filled with a glass in which is contained the "liquid fire." This chemical substance is prepared from a secret in the possession of Captain Norton, but the chief ingredients are phosphorus dissolved in bi-sulphate of carbon, and hermetically sealed. Immediately on this shell striking any ignitable matter the glass is broken, and so powerful is the liquid that it almost instantaneously sets the object in a blaze. During the experiments a number of large sacks were suspended on poles, to represent the sails of a ship, and these were soon soaked through with rain, so as to become completely saturated. Captain Norton then took a heavy three-grooved rifle, which he loaded with one of the shells, and fired at the canvas. Notwithstanding that the sacking was very wet the effect was exceedingly surprising, the liquid spreading through the canvas, which in a short time began to smoulder, and after another interval burst forth into flame, entirely consuming the whole. Had the sacking been dry the effect would have been instantaneous. Captain Norton can undertake, with the same description of shells, but of larger size, to set fire to any line-of-battle ship in the navy. The next experiments undertaken were with a new description of rifle-shot, which has been named the "Spinster." This bullet, which can be fired by Captain Norton at a distance of no less than 1800 yards, is intended for blowing up ammunition waggons, bags of gunpowder, or setting fire to the camp of an enemy. The bullet, which in shape and size resembles the Enfield rifle-ball, has a chemical substance attached to its base which becomes ignited the instant it is fired, remaining burning long enough to do the execution for which it is intended. A bag, containing about two pounds weight of gunpowder, mixed with some sawdust, was placed on the ground, the powder being soon wetted through by the rain. One of the "spins-

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ter" shots was fired at the mass by means of Captain Norton's gossamer seamless cartridge, but owing to the powder being so wet no immediate result followed, as the gunpowder was so mixed up with the sawdust. After a short time, however, the powder was ignited and blown up. Captain Norton afterwards exhibited some of his "frictional igniters," which are a kind of hand grenade, and can be made to explode when thrown from a glacis in the face of assailants. The Engineer Officers present expressed themselves in satisfactory terms at the result of the experiments made with Captain Norton's inventions.

Further experiments have been made with these shells* at the instance of the Royal Engineer Officers at Chatham. They were undertaken by Captain Norton for the purpose of proving that any line-of-battle ship or other vessel, could be easily set on fire by firing one or more of these shells into the hull. Some pieces of thick planking were erected at a convenient distance from the spot selected for the firing of the shell, which Captain Norton charged with the most minute portion—certainly not more than an ordinary tea-spoonful—of his "liquid fire." The shell was then placed in an ordinary large grooved rifle and fired at short range of the deal planking, against which it exploded, the glass containing the "liquid fire" immediately bursting and scattering its contents over the plank. The results were quite satisfactory, the planking in a very few moments bursting into flame, which burnt furiously until the plank struck was consumed. Then Captain Norton proceeded to test another invention of his, called the waterproof frictional igniting cartridge. This cartridge which consists of a small india rubber bag or casting, which holds a small quantity of powder, and also a simple contrivance for igniting it by means of friction. A cord leads from the frictional igniter within the bag, and this may be carried to any length. The waterproof bag being sunk,

* Captain Norton's Liquid Fire Rifle Shells.

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the slightest pull at the cord will ignite the powder, which explodes the large mass against which it is placed. The experiments showed the ease and safety with which submarine explosions can be carried on in any situation and at any depth. The remaining experiments made by Captain Norton were for the purpose of demonstrating the action of his concussion fuse, and also its frictional exploding signal, which, being attached to a cord and secured, the grenade may be thrown the required distance, when it will explode in the face of a body of assailants. As soon as a Government commission has been appointed Captain Norton's missiles will be subjected to a variety of tests.—*United Service Gazette.*

The Armstrong and Whitworth Guns.

Those who know anything of Mr. Whitworth's plans must be aware that the mere polygonal form which he gives to the bore of the cannon is by no means the whole of his invention. That form admits, for example, of hard metal projectiles being employed instead of compound shot, or shot coated with soft metal; and the piece, instead of being necessarily a breech loader, may be loaded at the breech or muzzle as required. Again, the Whitworth projectiles are variously adapted to suit special purposes. For ordinary practice, cast-iron shot, shaped by self-acting machinery so as to fit the hexagonal bore, are used. For firing through water, flat-fronted or punch-shaped projectiles are employed; and we have been informed on good authority that these flat-fronted projectiles have been fired through 30 feet of water, and after that have retained more than sufficient force to penetrate a ship's bottom. This is a most significant result, and one which promises to be of immense importance in connexion with naval armaments. These projectiles, if made of tough hard iron, may also be driven through the thickest wrought-iron plates that are made. They were tried last year at Portsmouth, in the presence of an Official committee, against the four-inch wrought-iron plates which we are now about to use as a casing

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for ships' sides. A 68lb. flat-fronted projectile, fired from a distance of 450 yards, perforated both the iron plate and the ship's side on which it was firmly bolted. It punched a huge saucershaped piece fairly out of the plate, and left a clean hole behind it. As we stated in a former number the gun from which the shot was fired burst; but this took place on a subsequent day. We were not then aware that the shot had successfully penetrated the plate and the ship's side in the manner explained. And this brings us to another important feature of the case. The gun used on the occasion referred to was an ordinary Government piece, cast solid on the old plan, and was inherently too weak to bear the strain caused by firing a long rifled projectile. But to test the invention fully and fairly, the gun should be constructed throughout on the improved plan of the inventor. The employment of a weak construction was illadvised and unfortunate, and probably caused blame to be imputed to the system of Mr. Whitworth, when the failure was due to the use of iron cast solid in large masses. The experiment, however, may be considered to have settled two very important questions, and shown—1st, that guns cast on the old plan are inapplicable for rifled cannon; 2d, that wrought-iron plates four inches thick are not shot proof at a range of at least 450 yards. Mr. Whitworth, in his treatise on rifled arms, reviewed in a late number of the *Mechanics' Magazine*, makes these remarks:—

"In comparing the strain upon a rifled cannon with that upon a smooth bore, the work done by the respective pieces must be taken into consideration. If the full powers of the former are to be exerted, and if the extreme ranges which it is capable of giving are required, a proportional greater strain will be put upon the piece on account of the elongated form of the shot, and more strength is therefore required. The mode of making large iron guns, by casting them in solid masses (as at present), is highly objectionable, and is certainly not suitable for bearing the full strains of a rifled gun. It is

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well known that if iron be cast in large masses, great irregularities will be produced in the metal during the process of cooling; and, beyond a certain limit, little or no increase of strength is gained by increasing its thickness. Improved modes of construction can, however, be adopted, which will admit of the gun being loaded at the breech when required, and will give all the strength necessary for as large a charge of powder as can be consumed with the projectile intended for the piece."

The concluding observations shows that Mr. Whitworth anticipates no difficulty in making his guns of sufficient strength; and it was not to be supposed that he would allow the matter to rest where it is. We were not, therefore, surprised to learn from General Peel, in the House of Commons on Monday last, that Mr. Whitworth is renewing his experiments with guns of greater strength. We wish him success in his undertaking.

As we have before said, there is a great mechanical promise in this system; and it is a fact, however strange it may appear, that no gun has yet been made in order to test that system thoroughly. Such a gun is now, however, in course of construction, and, notwithstanding the great capabilities of the Armstrong weapon, we shall look anxiously for the trial of the other. We are, we firmly believe, nearer the beginning than the end of ordnance improvements.—*Mechanics' Magazine.*

Royal Artillery.

GENERAL ORDER.

HORSE GUARDS, S. W.
1st April, 1859.

His Royal Highness The General Commanding-in-Chief has much pleasure in promulgating to the Royal Regiment of Artillery the consent of Her Majesty to the establishment of a school of Gunnery at Shoeburyness, to take effect from the 1st April, 1859,

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His Royal Highness avails himself of this opportunity of impressing upon the whole Regiment of Artillery a sense of the great benefit which ought to be derived by the Corps from the advantages which a school of Gunnery presents to all who shall enjoy the facilities which such an establishment will afford for individual improvement, as well as for the advancement of Artillery science in general.

As some little time must necessarily elapse before the details of a first-rate system of Artillery instruction can be arranged, His Royal Highness will, on the present occasion, content himself with indicating the General principles which will guide those Officers of the Corps whom he has entrusted with the preparation of that system, and although time and experience may suggest improvements in the details, the broad outline of the system will, doubtless, undergo little or no change.

An Artilleryman should unite with proficiency in his own branch of the service, many of the qualifications of a cavalry or Infantry Soldier; and it is therefore hoped that while Officers will naturally use their utmost endeavours to train efficient Gunners, they will not lose sight of the great advantages to be derived from a thorough knowledge of the drills and manœuvres of both services, in enabling them to conform with confidence and judgment to combined movements of all arms. For the furthering of this object, the directions contained in the recognised manuals are to be strictly adhered to, and it will be hereafter pointed out in a "course of instruction" what portion of the infantry manœuvres may be dispensed with by the Royal Artillery.

As an Infantry Soldier is not considered fit for the ranks as a duty-man until he is well versed in the proper management of his weapons, so an Artilleryman is to be considered a Recruit until he is properly instructed in the *essential* requisites of an Artillery Soldier. Commanding Officers of Artillery will, therefore, bear in mind that Gunners are not

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to be detailed by them for "duty" until dismissed Gun Drill. Thus, if attached to a Brigade liable to coast duty, a course of Garrison Gun Drill must be completed. With a view to rendering this period of probation as short as possible, "system" is absolutely necessary, and this system will be the subject of mature consideration by the staff of the school of Gunnery.

At all Artillery Stations opportunities are afforded for instruction in those mechanical operations (commonly called the Repository Course), which form such an essential portion of an Artilleryman's training, and Commanding Officers must adhere strictly to the distribution of time as allotted to the various departments of instruction, in order that uniformity of system may be maintained.

The instruction in the management of Rifled Ordnance will form the subject of special arrangements, and will, in the first instance, be carried on under the immediate superintendence of the Staff of the School of Gunnery, and be gradually disseminated throughout the Corps. It would now be premature to enlarge on this portion of the subject.

With regard to the theoretical instruction of the Non-Commissioned Officers and Men of the Artillery, His Royal Highness would remind Officers of the numerous opportunities which offer of impressing upon those under their command how inseparable Artillery practice is from the deductions of theory, and how a knowledge of the general rules of mechanical scienee will facilitate all operations, whether as regards the acquirement of good "Gunnery," or the management of heavy ordnance and military machines. Such opportunities should not be thrown away, and His Royal Highness trusts to the Officers of the Corps to impart to all under their instruction, as much as possible of that theory which is the ground work of all Gunnery. Difficulties will, doubtless, present themselves, but His Royal Highness is convinced

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that a determination and cheerful co-operation on the part of the Officers of the Royal Artillery will tend to obviate such difficulties, and that such assistance will be afforded him, his previous acquaintance with the Artillery Service leaves him no room to doubt.

On the formation of the School of Gunnery the Repository at Woolwich will be placed entirely under the Commandant, with an Officer of the School to carry on, under his orders, the Gunnery instruction of the Garrison; and should the Commandant find it necessary, he will detail Subaltern Officers to assist this Officer in his duties.

The following is the detail of the Staff of the School, viz:—

1 Commandant and Superintendent.
1 Field Officer and Chief Instructor.
3 Instructors in Gunnery.
1 Brigade Major.
1 Adjutant and Quarter Master.
1 Captain Instructor (Carbine).
1 School Master.
1 Serjeant Major.
1 Quarter Master Serjeant.
6 Serjeant Instructors.
1 Serjeant Conductor of Stores.
2 Orderly Room Clerks.
2 Storemen.

And His Royal Highness has appointed the following Officers to the School of Gunnery, viz.:—

Commandant and Superintendent.—Colonel Mitchell

Chief Instructor.—Brevet-Colonel Gardner.

Brigade-Major.—Brevet Lieutenant-Colonel S. E. Gordon.

Instructors in Gunnery { Major Ward (Woolwich).
Captain Hay
Major Taddy

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Carbine Instructor,—Captain T. Brown.

Adjutant and Quarter Master.—Captain Alderson.

By Command of

His Royal Highness The General Commanding-in-Chief.

(Signed) G. A. Wetherall
Adjutant General.

Distribution of Colonels and Field Officers of the Royal Artillery.

ROYAL HORSE BRIGADE.	
Name.	Station.
Colonel Bloomfield, C. B.	Woolwich
,, Teesdale	Employed
Lieut.-Col. and Bt. Col. Wood, C. B.	Aldershot
,, ,, Gambier, C. B.	Ireland
,, ,, Phillpotts	Woolwich
Lieut.-Col. Price, C. B.	India
1st BRIGADE.	
Colonel F. Warde	On Leave
,, Palliser	On Leave
Lieut.-Col. and Bt. Col. Dalton	Woolwich
,, ,, DeRinzy	Woolwich
,, ,, P. Maclean	Woolwich
Lieut.-Col. Broughton	Woolwich
2nd BRIGADE.	
Colonel Ingilby	On Leave
,, Cuppage	Dover
Lieut.-Col. and Bt. Col. Aylmer	Dover
,, ,, D'Aguilar, C. B.	Dover
,, ,, Gardner	Employed
Lieut.-Col. Montresor	Depôt
3rd BRIGADE.	
Colonel Pester	Devonport
,, Maclean	St. Helena
Lieut.-Col. and Bt. Col. Rowan, C. B.	Employed
,, ,, Wright	Devonport
,, ,, Henderson	Depôt
Lieut.-Col. Romer	Employed

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(CONTINUED.)

4TH BRIGADE.	
Name.	**Station.**
Colonel Flude	On Leave
,, Ormsby	Woolwich
Lieut.-Col. and Bt. Col. Francklyn, C. B	Woolwich
,, ,, Crofton	Woolwich
Lieut.-Col. Hon. Devereux	Shorncliffe
,, Gardiner	Shorncliffe
5TH BRIGADE.	
Colonel Burn	On Leave
,, Shuttleworth	Gibraltar
Lieut.-Col. and Bt. Col. Bingham	Staff, London
,, ,, Elwyn	Employed
Lieut.-Col. Maude, C. B	Employed
,, Maberly, C. B	Gibraltar
6TH BRIGADE.	
Colonel Thorndike	On Leave
,, E. C. Warde, C. B	Malta
Lieut.-Col. and Bt. Col. Kennedy	Depôt
,, ,, Irving, C. B	Corfu
Lieut.-Col. Wodehouse, C. B	Staff, London
,, Graydon	Malta
7TH BRIGADE.	
Colonel Taylor	Quebec
,, Crawford	On Leave
Lieut.-Col. and Bt. Col. Benn	Halifax
,, ,, Turner	Bermuda
,, ,, Paynter, C. B	Quebec
Lieut.-Col. Domville	Barbados
8TH BRIGADE.	
Colonel Gostling	On Leave
,, Lake, C. B	Portsmouth
Lieut.-Col. and Bt. Col. Fitzmayer, C. B	Leith
Lieut.-Col. Goodenough	Aldershot
,, Radcliffe	Aldershot
,, Nixon	Portsmouth
9TH BRIGADE.	
Colonel Symons	Employed
,, Dick	Ballincollig
Lieut.-Col. and Bt. Col. Marriott	Northern District
,, ,, Dickson, C. B	Staff, Dublin
Lieut.-Col. Shakespear	Ballincollig
,, Knox	Ireland

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(CONTINUED.)

Name.	Station.
10TH BRIGADE.	
Colonel Nedham	Sheerness
„ Dunlop, C. B	Guernsey
Lieut.-Col. and Bt. Col. Cleaveland	Jersey
„ „ Elliot	Guernsey
„ „ Mundy	Portsmouth
Lieut.-Col. R. Crofton	Alderney
11TH BRIGADE.	
Colonel Wingfield	On Leave
„ Poole	On Leave
Lt.-Col. and Bt. Col. Riddell, C. B.	Bengal
Lieut.-Col. Burrows	Bengal
„ Christie	Bengal
„ Adye, C. B	Bengal
12TH BRIGADE.	
Colonel P. Benn	On Leave
„ McCoy	On Leave
Lieut.-Col. and Bt. Col. Cockburn	Mauritius
„ „ Freese, C. B	Cape
„ „ Crawford, C. B	China
Lieut.-Col. Graham	Ceylon
13TH BRIGADE.	
Colonel Hill	On Leave
„ Morris	On Leave
Lieut.-Col. and Bt. Col. Buchanan	Bombay
„ „ Browne	Bombay
„ „ Smythe	Employed
Lieut.-Col. Younghusband	Employed
14TH BRIGADE.	
Colonel Mitchell	Employed
„ St. George, C. B	Employed
Lieut.-Col. and Bt. Col. Barker, C. B	Bengal
„ „ Faddy	Madras
Lieut.-Col. Dennis	Bengal
„ Travers	Depôt
DEPOT BRIGADE.	
Lieut.-Col. and Bt. Col. Kennedy	Woolwich
„ „ Henderson	Woolwich
Lieut.-Col. Montreson	Woolwich
„ Travers	Woolwich

Supernumerary Colonels and Field Officers will be transferred to the Depôt Brigade.

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Nature of Duty.	Brigade.	Batteries.	Stations.	Brigade Staff. Serjeant Major.	Quarter Master Serjeant.	Trumpet Major.	Orderly Room Serjeant.	Paymaster Serjeant.	Repository Serjeant.	Drill Serjeant.	Hospital Serjeant.	Armourer Serjeant.	Establishment per Battery. Staff Serjeants.	Serjeants.	Corporals.	Bombardiers.	Gunners.	Drivers.	Trumpeters.	Farriers.	Shoeing Smiths.	Collar Makers.	Wheelers.	Total	Horses per Battery.	Remarks.
Garrison Duty.	1st	1 to 8	Woolwich	1	1	1	1	1	1	..	1	1	1	6	4	4	100	....	2	..	..	..	..	117	....	
	2d	1 to 7	Dover	1	1	1	1	1	1	..	1	1	1	6	4	4	100	....	2	..	..	..	..	117	....	
	3d	1, 2, 3, 5, 6 and 8.	Devonport										1	6	4	4	100	....	2	..	..	..	..	117	....	
				1	1	1	1	1	1	..	1	1														
		4 and 7.	Portsmouth										1	6	4	4	100	....	2	..	..	..	..	117	....	
	5th	1 to 8	Gibraltar	1	1	1	1	1	1	..	1	1	1	6	4	4	110	....	2	..	..	..	..	127	....	
	6th	1 to 4, 8 and 9	Malta										1	6	4	4	110	....	2	..	..	..	..	127	....	
				1	1	1	1	1	1	..	1	1														
		5, 6, 7, and 10	Corfu										1	6	4	4	110	....	2	..	..	..	..	127	....	
	7th	1	Jamaica										1	6	4	4	100	....	2	..	..	..	..	117	....	
		2	Bermuda										1	6	4	4	100	....	2	..	..	..	..	117	....	
		3 and 4	Quebec	1	1	1	1	1	1	..	1	1	1	6	4	4	100	....	2	..	..	..	..	117	....	
		5 and 6	Halifax										1	6	4	4	100	....	2	..	..	..	..	117	....	
		7	Barbadoes										1	6	4	4	100	....	2	..	..	..	..	117	....	
	10th	1 and 7	Alderney										1	6	4	4	100	....	2	..	..	..	..	117	....	
		2 and 3	Portsmouth										1	6	4	4	100	....	2	..	..	..	..	117	....	
		4, 5, & 6	Guernsey	1	1	1	1	1	1	..	1	1	1	6	4	4	100	....	2	..	..	..	..	117	....	
		8	Jersey										1	6	4	4	100	....	2	..	..	..	..	117	....	
	12th	1	St. Helena										1	6	4	4	100	....	2	..	..	..	..	117	....	
		2, and 4	Mauritius										1	6	4	4	100	....	2	..	..	..	..	117	....	
		3	Sydney	1	1	1	1	1	1	..	1	1	1	6	4	4	100	....	2	..	..	..	..	117	....	
		5	Ceylon										1	6	4	4	100	....	2	..	..	..	..	117	....	
		6	China										1	6	4	4	100	....	2	..	..	..	..	117	....	
		7	Cape										1	6	4	4	100	....	2	..	..	..	..	117	....	
Field Battery Duty.	4th	1, 2, 4, 6,	Woolwich										2	8	6	9	100	75	2	1	6	3	2	214	104	
				1	1	1	1	1	....	1	1	1														
		3, 5, 7, 8,	Shorncliffe										2	8	6	9	100	75	2	1	6	3	2	214	104	
	8th	1	Devonport										2	8	6	9	100	75	2	1	6	3	2	214	104	
		2	Northampton										2	8	6	9	100	75	2	1	6	3	2	214	104	
		3, 4, 5, 8,	Aldershot	1	1	1	1	1	....	1	1	1	2	8	6	9	100	75	2	1	6	3	2	214	104	
		6	Christchurch										2	8	6	9	100	75	2	1	6	3	2	214	104	
		7	Hilsea										2	8	6	9	100	75	2	1	6	3	2	214	104	
	9th	1 to 8	Ireland	1	1	1	1	1	....	1	1	1	2	8	6	9	100	75	2	1	6	3	2	214	104	
	11th	1 to 8	Bengal	1	1	1	1	1	....	1	1	1	2	8	6	9	100	70	2	1	6	3	2	209	....	
	13th	1 to 8	Bombay	1	1	1	1	1	....	1	1	1	2	8	6	9	100	70	2	1	6	3	2	209	....	
	14th	1 to 5	Bengal										2	8	6	9	100	70	2	1	6	3	2	209	....	
				1	1	1	1	1	....	1	1	1														
		6 to 9	Madras										2	8	6	9	100	70	2	1	6	3	2	209	....	

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On Gauges and Windage.

By Colonel Croggan, Madras Artillery.

"Windage is the difference between the diameter of the "shot and the calibre of the piece of ordnance. It has been "found by experiments that with the windage formerly esta- "blished in the British Service, between one-third and "one-fourth of the force of the powder escaped and was lost, "and that, as balls were often less than the regulated size, "it frequently happened that half the force of the powder "was lost by unnecessary windage, and the shot from acquir- "ing a zig-zag motion, did not generally quit the cylinder in "the direction of its axis. The diameter of the shot was the "datum from whence the quantity of windage and calibre of "the gun were originally determined. Thus the diameter of "the shot was supposed to be divided into 20 parts—one of "these was allowed for windage, and the calibre of the gun "made equal to the sum of that diameter and windage. Thus "the diameter of a 24lb. shot being 5.547 inch; $\frac{1}{20}$ of it, "or ·277, was allowed for windage; and 5.547 + 277=5·824 "inch, was the calibre of the gun."

"The Carron Company availing themselves of the dis- "coveries made in the ballistic experiments lessened the "calibres of their new ordnance, to admit ordinary shot at "reduced windage. From this circumstance great confusion "and complications have arisen. The shells for guns are "of the same diameter as their shot; but carronade shells "are smaller by about ·1 of an inch. Now if carronades "admit ordinary shot there can be no reason why their shells "should be smaller;—that is, there can be no reason why the "windage should be greater for a shell than for a shot. This "indeed is practically admitted by the windage allowed for "mortars and howitzers which is only ·15 of an inch for all "natures, excepting the $4\frac{2}{5}$ inch, which is ·2 inch."

"Any alteration in the regulated windage should evidently "be made by casting new shot, and not by making new guns;

"it follows, therefore, that if windage is at all to vary according to the nature of the gun, the expression should be taken from its calibre, and not from the diameter of the ball. Thus, instead of expressing the windage by $\frac{1}{20}$ (or whatever it may be altered to) of the diameter of the shot, it is much more simple, and more natural, to change the denomination to $\frac{1}{21}$ of the calibre of the gun, and to express the diameter of the shot by $\frac{20}{21}$, thus adopting the calibre of the gun as the standard. But why should windage be so regulated at all? The proofs to which the bores of guns, and the shape of shot are now submitted, authorize us to rely upon the former being perfectly cylindrical, and the latter correctly spherical; and consequently no allowance need be made for any degree of inaccuracy. What then are the considerations which should be provided for in determining the degree of windage? 1stly, the expansion of shot by a white heat. 2ndly, the incrustation of a little rust. 3rdly, the foulness of the cylinder in continued firing; and 4thly, the thickness of the tin straps for wooden bottoms. These do not require that the shot should bear a certain fixed proportion to the diameter of the gun, but merely that a sufficient allowance be made to insure the admission of the shot under all these circumstances."

"The degree of expansion of shot by white heat, is found to be about $\frac{1}{70}$ of the diameter of the shot for a 24-pounder, $\frac{1}{76}$ for a 16-pounder; and $\frac{1}{82}$ for a 6-pounder."

"The French allow 1 line 6 parts for the windage of heavy or siege ordnance and 1 line for field ordnance. The former reduced to English measure, is ·133 of an inch and the latter about ·088, which are not much than $\frac{1}{3}$ of the windage in the British Service."

"The calibre of a French 24-pounder is 5 inches, 7·625 lines, and the windage (= 1·5 lines) or about $\frac{1}{45}$ of the calibre of the gun."

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" The calibre of a French 8-pounder is 3 inches 11 lines, " or 47 lines; and the windage is one line, or $\frac{1}{47}$ of the calibre " of the gun."

" If then windage must be proportional to the shot or " gun, it may safely be decreased to $\frac{1}{48}$, or at most $\frac{1}{35}$ of the " calibre."

" But the impediments to the entrance of the ball into " the cylinder bear no relation to the magnitude of the " cylinder or ball, excepting the expansion of the latter by " heat; and that, in the largest balls, is only, on an average, " $\frac{1}{70}$ of the calibre, or half of the proposed windage $\frac{1}{35}$, so " that there appears to be no reason why the difference " between the ball and cylinder should vary with the different " cylinders. The windage of carronades recognises this reason- " ing; for it is fixed at ·15 of an inch for the three higher " natures, viz., for 68, 42, and 32-pounders; ·14 is allowed " for 24-pounders; ·12 for 18 and 12-pounders; and ·15 is " the allowance for the windage of all higher natures of " mortars and howitzers."

" Suppose the windage of a 24-pounder (¼ of an inch) " were adopted for all the higher natures of ordnance, this in " the 24-pounder would be $\frac{1}{45}$ of the calibre; but the French " allowance (which as we have seen does not vary with the " nature of the gun) is only $\frac{1}{45}$ of the calibre in the " 24-pounder. Now no degree of foulness from quick firing, " and no coating of rust that should be suffered to remain " on a shot, is equal to ·07—(about $\frac{1}{15}$ of an inch—which a " windage of ¼ would allow. If, therefore, we adopt ¼ for the " windage of heavy guns, we proceed upon a certainty in the " improvement; and perhaps, ·13 of an inch is windage suffi- " cient for all natures of guns and carronades, from the " 68-pounder carronades to the 12-pounder inclusive; and " downwards from the 9-pounder inclusive, ·1 or ·11 may be " recommended."

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" After a course of experiments the Artillery Select " Committee at Woolwich fixed one tenth of an inch as " the windage for field guns, and ·15 of an inch for all " natures of siege and garrison guns, from the 12-pounder " upwards."

" A diminished rate of windage has been adopted in the " Naval Service in a partial shape, which has produced a com- " plicated difficulty caused by a vast number of carronades " of smaller calibres than guns of the same nature having been " introduced; these present a formidable obstacle, which " might however be obviated by reaming up the bores of " carronades to an equality with those of guns of like nature. " But as carronades are considered useless in the present state " of the Naval armaments, they should be discarded from the " Service as soon as possible. Some relaxation has been per- " mitted in the dimensions of shot gauges, to diminish a little " the windage of guns; and shot has been received into " arsenals and circulated in the service considerably above " gauges for carronades:—but no partial reduction of windage " can be made in this manner without making the shot too " large for carronades of like nature."

" With respect to the quantity of win dage which may be " considered proper for all natures of iron ordnance from the " 12-pounder upwards, there cannot be any doubt that ·15 inch " would be sufficient; consulting experience on this head " we know that ·14 is the quantum regulated for the " 24-pounder carronades, we know also that the windage of " all French iron ordnance reduced to English measure is " only ·133 of an inch."

Having arranged the foregoing remarks on reference to Sir Howard Douglas's Treatise on Naval Gunnery—I will now apply the subject with reference to the Tables of Gauges recently published by the Madras Artillery Select Committee.

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Table exhibiting the established diameters of bores of Ordnance, and the difference between the gauges in use and the diameter of bores.

Nature of Ordnance.	Diameter of Bore.	Difference between diameter of bore and Gauges. For Common shells and Spherical Case Shot. High.	For Common shells and Spherical Case Shot. Low.	For shot or Common shells. High.	For shot or Common shells. Low.	Remarks.
Guns. 12 Inch...	12	·12*a*	·2*a*			*a* For Hollow Shot.
Guns. 10 Inch...	10	·125*a*	·175*a*			
		·13*b*	·18*b*			*b* S. C. S. and C. S.
,, 8 ,, ...	8·05	·1*c*	·15*c*			*c* S. C. S—C. S. and Hollow Shot.
Howitzer 10 ,, ...	10	·12	·2			
,, 8 ,, ...	8	·1	·18			
	For	Spherical	Case.			
Guns 68 ,, ...	8·12	·22	·30	·17*d*	·22*d*	*d* ForShot, Common shells and Hollow Shot.
,, 56 ,, ...	7·65	·14	·20	·14*d*	·20*d*	
,, 42 ,, ...	6·93*e*	·14	·185	·135*g*	·195*g*	*e* 9 ft 6 in.
,, 32 ,, ...	6·41*f*	·203	·266	·203	·267	10 ft 6·97 in.
,, 24 ,, ...	5·823	·203	·253	·184*g*	·239*g*	*f* 6·37
,, 18 ,, ...	5·29	·17	·22	·166	·226	6·35
,, 12 ,, ...	4·623	·147	·191	·083*g*	·118*g*	6·308
,, 9 ,, ...	4·20	·1	·14	·083*g*	·118*g*	*g* For Shot only.
Mortars 13 ,, ...	13	·12	·2			
,, 10 ,, ...	10	·12	·2	......	....	For Common shells only.
,, 8 ,, ...	8	·1	·18			
Brass Howitzer 24 Pdr....	5·72*h*					*h* 24 Pdr. English.
,, ,, 24 ,, ...	5.66	·04	·09			12 ,, ,,
,, ,, 12 ,, ...	4·58*h*					
	4·52	·044	·09			
Brass Mortars 5½ ,, ...	5·62	·0	·05	......	....	For Common shells only.
,, ,, 4⅖ ,, ...	4·52	·05	·09			
Brass Guns 9 Pdr....	4·2	·1	·14	·083*g*	·118*g*	
,, ,, 6 ,, ...	3·668	·1	·136	·083*g*	·118*g*	
,, ,, 3 ,, ...	2·91	·077	·107	·072*g*	·102*g*	

The foregoing Table serves to shew the arbitrary and irregular manner in which the dimensions of shot and shells and of Gauges have been arranged;—the windage of shot for the 68-pounder gun is less than that for the 32 and 24-pounders, the windage allowed for spherical case shot for iron guns is considerably greater than that for common shot; for which I can see no sufficient reason; the reverse I consider ought to be the case, as spherical case shot requires the least possible windage to ensure the projectile leaving the gun with the greatest velocity, the straps to attach the wooden bottom to the spherical case shot would not it is believed require more than ·05 of space at most.

The Gauges of the Mortars, Howitzers and Brass Guns appear to have been arranged with some degree of method,

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with the exception of the high gauge of the 5½ inch mortar, which is of the same diameter as the bore, and leaves no windage.

I cannot see any necessity for having separate Gauges for hollow shot, for spherical case, and for shot only; instead of which I would establish one high and one low gauge only for each piece.

In arranging the following Tables I have adopted as far as practicable the recommendation of the Select Committee at Woolwich, observing at the same time, the established dimensions of projectiles and gauges.

Nature of Ordnance.		Windage, or difference between diameter of bore and diameter of projectile.	Difference between diameters of high and low gauges.
	Iron.		
Guns	13 and 10 inch....	·15	·06
"	8 inch	·13	·06
Howitzer	10 and 8 inch......	·15	·06
"	8 inch............	·13	·06
Guns	68—56—42—32		
	24 and 18 Pdrs...	·15	·06
"	12 and 9 " ...	·1	·06
Mortars	13 and 10 inch...	·15	·06
"	8 inch............	·13	·06
	Brass.		
Howitzer	24 and 12 Pdrs...	·065	·04
Mortars	5½ and 4⅖ inch...	·05	·05
Guns	9 and 6 Pdrs....	·1	·04
"	3 Pdrs.	·09	·04

In the following Table half the difference between the diameters of the gauges has been added to the diameter of the projectile for the High gauge, and half has been substracted from the diameter of the Projectile for the Low Gauge.

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Table of the calibres of Ordnance exhibiting the proposed diameters of projectiles and of high and low gauges.

Nature of Ordnance.		Diameter of bore. inches.	Proposed Diameter of Projectile. inches.	Proposed Diameters of Gauges for all Projectiles. High inches.	Low inches.
	Iron.				
Gun	12 inch	12	11·85	11·88	11·82
,,	10 ,, ...	10	9·85	9·88	9·82
,,	8 ,, ...	8·05	7·92	7·95	7·89
Howitzers	10 ,, ...	10	9·85	9·88	9·82
,,	8 ,, ...	8	7·87	7·90	7·84
Gun	68 Pdr.	8·12	7·97	8·	7·94
,,	56 ,, ...	7·65	7·50	7·53	7·47
,,	42 ,, ...	6·93	6·78	6·81	6·75
,,	32 ,, ...	6·41	6·26	6·29	6·23
,,	24 ,, ...	5·823	5·673	5·703	5·643
,,	18 ,, ...	5·29	5·14	5·17	5·11
,,	12 ,, ...	4·623	4·523	4·553	4·493
,,	9 ,, ...	4·20	4·1	4·13	4.07
Mortar	13 inch............	13	12·85	12.88	12·82
,,	10 ,, ...	10	9·85	9·88	9·82
,,	8 ,, ...	8	7·87	7·90	7·84
	Brass.				
Howitzer	24 Pdr............	5·66	5·595	5·625	5·565
,,	12 ,, ...	4·52	4·455	4·475	4·435
Mortar	5½ inch............	5·62	5·57	5·595	5·545
,,	4⅖ ,, ...	4·52	4·47	4·495	4·445
Gun	9 Pdr............	4·2	4·10	4·12	4·08
,,	6 ,, ...	3·668	3·568	3·588	3·548
,,	3 ,, ...	2·91	2·82	2·84	2·80

As Shot, Shells, and Ordnance are chiefly supplied from England it is evident that whatever is written in this country must be of a suggestive nature, but I hope that my attempt to reduce the subject to a system may be found of some value.

(Signed) J. W. Croggan, Colonel,
Madras Artillery.

Saint Thomas' Mount,
14*th October* 1859.

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French Land Transport.

COMMUNICATED.

General Codrington to Lord Panmure.—(Received February 7.)
(No. 114.)

Sebastopol, January 26th 1856.

MY LORD,

I INCLOSE a full and valuable report from Major-General Sir Hugh Rose, as requested in your Lordship's despatch No. 11 of the 16th November 1855.

I have not even time to read it, as it came only this morning. It may be of consequence for you to see at once, and it is therefore sent off; but I should not be sorry to have the whole reports (except General Rose's which I have copied) sent to me again to read.

I have, &c.
(Signed) W. J. CODRINGTON.

INCLOSURE 1.

Report.

French Head-Quarters, Crimea,
January 20, 1856.

MY LORD,

IN compliance with your Lordship's instructions, conveyed to me in your despatch No. 11 to General Sir William Codrington, to report for your Lordship's information upon the system of Land Transport of the French Army, I have the honour to say that I lost no time in acquainting Marshal Pélissier with your wish, requesting him at the same time to have the goodness to permit me to give effect to it. His Excellency, with his usual desire to do all in his power to meet the wishes of his English Allies, willingly assented, and advised me to address myself to the "Intendant Général," M. Blanchant, who

French Land Transport.

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has the direction of the French Military Transport, "le Train des Equipages Militaires," which for brevity I shall call the "Train," for any information I might require. This Officer, as obliging as Marshal Pélissier, suggested that he should give me a note or memorandum on the "Train," in which he would give particular information respecting a part of it, of peculiar interest to your Lordship, the "Compagnies Auxiliares," composed chiefly of foreign elements, and raised in the East, specially, for the purpose of meeting the extraordinary demands of the French Army for transport in the Crimea.

It was not till the 19th instant that the "Intendant Général" was enabled to give me this note. In the meantime I have translated a report by the Minister of War of the 24th of February 1852, on the re-organization of the "Train," to the Prince President; it is brief and clever, and a history of this establishment, which I venture to think may be of use, because it shows the evils connected with Military Transport, which for some time baffled even the military knowledge and experience of French Generals, notwithstanding that they were engaged in great and constant wars, in which Military Transport—the life and legs of the army, as it may be called—played of course a very important part. Those evils were chiefly:—

Inclosure No. 2—Marshal de St. Arnaud's Report.

1*stly*. Making use of civil, that is, non-military, elements for an essentially military purpose, Military Transport.

2*ndly*. Supplying the material for the "Train" by means of contracts, instead of by work performed by responsible servants of the Government in Military Establishments.

3*rdly*. Letting down the "Cadres" of Military Transports in time of peace. The consequence was, that when war broke out, or extraordinary occurrences arose, the opera-

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tions of the army were impeded by a Military Transport insufficient at the time, and inefficient afterwards.

Marshal de St. Arnaud's Report gives further very useful information respecting the "Train." We learn from it the first establishment of Light Transport, at first called "Battaillon Léger," afterwards "Compagnies Légères," for a service of which the importance cannot be rated too high—the conveyance of wounded from the field of battle, and of the sick from the regiments to the ambulances, and from thence, if necessary, to the sea. We see that the Emperor Napoleon and Marshal Bugeaud, who certainly knew in a remarkable degree how to stimulate their troops to give proofs of rare courage and devotion, and profit by their fruits, considered the establishment of a transport for the sick and wounded, not only as a duty to humanity, but, particularly as regards the wounded, as an indispensable means for keeping up the *morale* of their troops. Your Lordship will see how strongly and clearly Marshal Bugeaud expresses himself on this subject. Transport of the wounded from the field of danger to a good ambulance, besides satisfying the rights of humanity, and sustaining that spirit of confidence in the soldier, which, like discipline, should never leave him, has, as stated in the report, another admirable effect,—it obviates the incalculable disadvantage of troops engaged in action leaving their ranks for the purpose of carrying off the wounded. Certainly, good soldiers have no other motive in leaving their ranks for this purpose than sympathy for a suffering comrade. But, on the other hand, all know that on a field of battle there are at times men of a different description, who either seek rest or refreshment, or are as desirous of placing themselves as their comrades in a place of safety; and four or five such men are seen assisting to the rear a man for whom one attendant would be sufficient. Nothing is so likely to insure a reverse in action as the want of confidence, and the gaps caused by

men leaving their ranks to carry away the wounded, which is most practised when it is most prejudicial, at the time and places when and where the enemy has caused the most casualties, and consequently when every available man should be present and ready to fill up broken lines and assist by his concurrence and example in resisting or attacking the enemy. As the report truly says, "Provided with a thoroughly well organized 'Train,' a Commander-in-Chief might, on the eve of battle, forbid his soldiers to quit their ranks." I cannot imagine an order more likely to insure success, and it must not be lost sight of, that although soldiers leaving their ranks assist the wounded, they expose thereby to disaster or destruction a part, if not the whole, of an army.

Whenever French troops are employed, whether on a reconnaissance or any more decided operation, a detachment or section of the Ambulance Train accompanies them, and remains at the point, from whence, by a short line, they can proceed quickly to load the wounded, in which duty they are assisted by detachments of "Infermiers," hospital attendants. If the detachment is a large one, as in the case of a division being engaged, it is under the orders of a Sous-Intendant.

There are two sorts of mule-litters, the "cacolet," so called from being used by the peasants of Bordeaux in carrying milk ("caque au lait"), and the "litieres de mulet:" the former is a fauteuil, or arm-chair, in which a soldier, not severely wounded, sits upright. The cacolet has an advantage which the mule-litters have not; the arm-chair folds in, and forms a pack-saddle, so that the cacolet can be used for all sorts of transport. The second is a couch, with a linen awning to shelter the men from sun and rain, in which a man severely wounded lies down. I have seen both of these transports go into every sort of ground, in short, wherever a mule can go; and, with admiration, I

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have seen them carrying away, on one side a French soldier, and on the other his fallen enemy. Of course it would be imprudent, and would neutralize their good, were the Ambulance Transports unnecessarily exposed to fire. But the French "Train" and their chiefs, the officers of the Intendance and of the "Train," are always most ready to face danger, when it is necessary that they should do so.

Excellent as are the cacolets and mule-litters for the transport of sick in ground where carriages are of no use, they, on account of their rough motion, are not so good for that purpose on even ground or roads suited to wheels; there are also, at times, difficulties in finding a double load for these mule equipages. There is a light, strong, two-wheeled carriage, invented in Algeria expressly for ambulance duty, which is free from these drawbacks. It it called after the inventor, "la voiture Maçou." It is on C springs, carries two men, and is drawn by one mule: its motion is so easy that officers wives, who went in them from Bonn to Constantine, found them easy as a town carriage. The French brought no carriage of this sort. I venture strongly to recommend their adoption.

Your Lordship will observe, that the result of the long and valuable experience detailed in Marshal de St. Arnaud's Report on Military Transport was the adoption of five squadrons, of which one is depôt; each squadron of four companies for service in war; the whole of the skeletons ("cadres") are "dêdoublées," which gives thirty-five service companies, that is, with carriages, and part "légères," with mules and horses, and five depôt companies.

Marshal de St. Arnaud calculated that, allowing for the amount of transport necessary for Africa, there would be about twenty-six companies for service in Europe, which he considered sufficient for the transport service of 300,000 men. Nothing can prove more the difficulties connected with transport service, and the necessity of calculating carefully

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every possible contingency connected with it, than the fact that this calculation, founded on a long experience and ample details, is erroneous; for the French army in the East does not reckon half 300,000 men, and yet the twenty-six companies were not sufficient for its transport service, and it became necessary, this year, to raise at one time as many as nineteen auxiliary companies to meet its wants.

An army making war in Germany, Italy, in short, in any country where there are ample means of transport, requires less transport than it would do in Turkey, the Crimea, or countries where the population is small and, consequently, transport is scarce; or where an enemy, like the Russians, is enabled to carry away or destroy the means of transport. For it must be remembered that in countries where there is little to eat there is also little transport, and that, consequently, a numerous transport is required to carry the provisions of an army operating in them. Deficiency of food and transport have more than once saved Constantinople from foreign armies—one of the numerous proofs of the value of transport.

Your Lordship will see that the report says that the action of command, that is of the "Train," combined with that of the "Intendance," render superfluous the formation of a special staff for it. The command of the "Train," or military transport, is the most important part of it.

Good drivers, horses, carts, in short, all the material of a transport, can be obtained. But if the transport itself be not under the direction of an authority who appreciates its immense value, knows how to manage and husband it, and has influence enough to protect it against encroachments, it will infallibly become inefficient and break down altogether.

Your Lordship will see, in the last paragraph but one of the Report, a proof of the conviction of the French Ministry of War, that Land Transport should be a purely military institution in all its details, even the manufacture

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and repair of the material, carriages, &c. For this purpose, Marshal de St. Arnaud proposes the organization of three companies of Military Transport workmen, to be distributed in the parks of construction and repair.

The Minister of War closes his report by submitting to the Prince President the "project of a decree" for the reorganization of the "Train" of Military Equipages, of which I have the honour to inclose a copy; it is so clear that it requires hardly any explanation, more especially as all the details which it contains appear also in the note of the "Intendant Général" on the Military Transport of the French army in the East, of which I also inclose a copy. It is a document full of valuable information, particularly as regards the native or auxiliary companies, organized for service in the East.

Inclosure No. 3. Decree.

Inclosure No. 4. Intendant General's Report.

I shall venture to direct your Lordship's attention to the matters of principal interest in the note, adding such information respecting them as I have derived from any personal experience.

The note commences with a notice of the three sorts of transport of a French army in the field—the Train of the Artillery, Engineers, and Military Equipages.

The French soldier carries in his knapsack and pouch two pockets of cartridges, varying in number from fifty-five to sixty rounds; the Artillery carries the rest of his ammunition. I have the honour to inclose to your Lordship, the copy of a note which General Thiry, commanding the French Artillery, has had the goodness to give me; it furnishes correct details on this subject.

Inclosure No. 5. General Thiry's note.

Reckoning the French Division at 8,000 men, the twelve Infantry caissons of the two batteries of 12-pounders, attached to each division, carry about 30 rounds for each man. The "Batterie de la reserve générale," the "Parc

mobile de reserve," and " la partie mobile du grand parc de campagne," carry about 30 more for each man.

Parks are merely Artillery carriages which march with the reserves. As fast as the ammunition Infantry caisson of the divisional batteries are exhausted, they are sent to the reserve, and full caissons sent back in their place.

The Artillery " Train" transports pontoons, and the means of making bridges " à support mobile."

Inclosure No. 6. General Frossard's note.

I have the honour to inclose an extract of a note on the " Train" of the Engineers, which General Frossard, commanding the Engineers was so obliging as to give me.

The Engineers' " Train" carries the means of making bridges " à supports fixées," and also bridges " à supports mobiles," when they are to be constructed, like rafts, with materials found on the spot.

Your Lordship will see that the requirements of war rendered necessary the increase of the five squadrons of the " Train," re-organized by the decree of the 19th of February 1852, to six squadrons, and that of the three companies of " Ouvriers constructeurs," to five companies.

The note shows how the strength of the five squadrons is increased from the peace to the war establishment, by the " dédoublement des cadres existants," that is, by the officers and non-commissioned officers of the old companies furnishing newly raised companies wholly with officers, and partly with non-commissioned officers.

Each of the new companies is called No. 1 " bis," No. 2 " bis," and so on. A veterinary surgeon is also added to each of the " bis" companies. The old or peace companies have more officers and non-commissioned officers than they require, for the express purpose of furnishing, in the event of war, officers and non-commissioned officers to the new " bis" companies. For although men are found fit for the

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"Train," it is impossible to find officers and non-commissioned officers who are qualified for this peculiar service. Even as it is, the experience of the Crimean campaign shows that it would be desirable that the companies should have more "surveillance," more officers and non-commissioned officers, particularly as the auxiliary or provisional companies must be formed by officers and non-commissioned officers of the regular companies of the "Train." I should state that conscripts accustomed to horses and vehicles, such as coachmen, postboys, carters, &c., are drafted into the "Train."

In France, and there is no reason, I think, why it should not be the same in other countries, the "Train" in time of peace is anything but an useless expense. It affords the means of cheaply and quickly augmenting the "Train" in the event of war; and it enables the troops provided with transport for food and ambulance material, to act, in cases of tumult, with no other than military resources, when the perturbators of public peace seize on public and private vehicles, the bakeries, stores, &c.

In France, the bread for the army is made in the military bakeries ("manutentions"), and the "Train" conveys it to the troops. The French ration-bread is very good, superior to London or contract bread. The "Train" is, besides, of much use, especially in Paris, Lyons, and other large towns, in carrying all sorts of military transport.

The "manutentions" in France have the same twofold advantage as the "Train." In peace, they prevent the troops being deprived of bread by rioters or insurgents, and they afford the means of organizing the military bakeries for war.

As regards the "Uniform of the Train," the "Pantalon à fausses bottes" is, I think, bad; the straps and buttons soon break; the bottom of the "Pantalon" is worn away by the constant mud and wet in winter.

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The life of the trooper of the "Train" is hard. From early in the morning, till often late at night, he is exposed to all the inclemency of the weather; and if a carriage breaks down, he must pass the night on the road—his feet are benumbed with cold and wet. It is true that he sleeps in ordinary circumstances at home; but he has not, during a long day, the intervals of rest and shelter like the sentry. The French "Train" would be all the better for waterproof clothing and high boots.

The note gives useful information on the important subject of transport vehicles; it justly condemns the caisson and approves the chariot, called also "prolonge."

The caisson is a sort of fourgon, on grasshopper springs; it was invented two or three years ago. Its springs prevent it crushing the loaves of bread, and its facility of turning is great. But, on the other hand, it is heavy, requiring two animals to draw it without a load. The wheels are narrow, the consequence is that I have seen it often sticking in a bad road where the chariot passes. The springs of the caisson, if broken on a line of march, could not be repaired.

The caisson is a town, but not a service, carriage; it carries from 1,000 to 1,200 kilos: the kilo is a little more than two English pounds.

The chariot, called also prolonge, is a very good carriage, and of simple construction; but I have frequently seen its "cheville ouvrière," by means of which it turns, or the part near it, broken. If this defect were remedied, it would be an excellent service carriage, being low, light, simple, and strong.

The French have introduced into their provisional companies of the "Train," a good charette, used in the provinces in France; it is on two wheels, well balanced, strong, and carries a load of 500 kilos; it is an improvement on the Maltese cart, which carries 300 kilos.

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The French approve, and with reason, a small four wheeled Russian transport cart, of which they have taken several; it has very much the shape of a boat, and many think that it might be made to serve as such in case of necessity.

I have ventured to dilate on different sorts of carriages, because it is one of the most essential details of transport. But carriages impede the operations of an army, far more than bad horses. A broken-down horse can be got out of the way or replaced; not so a broken carriage.

Marshal Bugeaud's opinion, like all the opinions of that great military genius, is wise, that wheel transport in military operations should remain with the reserves. One or two broken carriages, in a defile, causeway across a morass, or in a road through a thick forest, prevent the passage of Artillery and Cavalry, retard that of Infantry. I saw a cantinière's cart stick in a gorge under "Kaden Ootar," and stop the march of a division.

An army could not dispense altogether with wheel transport, because a vehicle drawn by two animals conveys about double what two bât animals can carry; and if an army had only bât animals it would require such numbers of them as to render impossible the transport of their forage.

As regards the relative proportion of transport to troops, it may be assumed, as a general rule, that a division of 10,000 men requires 10 carriages, with four horses, and fifty or sixty bât animals, to perform their ambulance service, and fetch their provisions and forage at a day's distance.

The note states that the "Train" is under the "Intendance." A short disgression for the purpose of examining the theory tested by experience, which is the basis of French military institutions, will show why the great system of army supply and transport is placed under that department.

The French have studied the nature of each branch of their military service. They have classed together, as much

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as possible, analogous duties, and they have intrusted the performance of them to departments, few in number, and composed of officers qualified by education and conduct for their respective duties.

The framers of the French system have attained the object they had in view. The army at large know to what department communications are to be addressed. Each department has the means within itself of executing its share of military details, without the delay and complication which so often result from a reference to other departments. And, above all, the head and time of the Commander-in-Chief, not being occupied with matters of detail, he has time to perform his special calling; to inspect his troops; watch over discipline, and the execution of their duties by the several departments; to plan operations against the enemy; compose his correspondence; and give decisions in matters of his competence.

All staff duties, that is, details relating to movements, discipline, promotion, rewards, military or political information, dress, &c., are performed by the Etat-Major. The Etats-Majors, whether of the Commander-in-Chief, or of Generals of corps or divisions, have no initiative. They are simply "cabinets" or "bureaux" (offices) of their respective Generals. All communications relating to staff duties are addressed to the chiefs of the respective Etats-Majors, who direct them into the proper channels of his department.

Military payments of whatever nature, as being matters of finance, are made by "Payeurs," officers of the Ministry of Finance. The Intendance is thus relieved of the responsibility and trouble of making the cash payments of an army, and of keeping the accounts belonging to them.

The Intendance exercises a surveillance over the "Payeurs," and issues to them the "mandates," money orders, without which no payments can be made.

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The Post-Offices of the army, as connected with finance, are under the "Payeurs," who, as well as the post-office agents, are stationed at the "Grand Quartier-Général," and with corps and divisions. I beg to be excused for making this digression, but it is necessary, in order to show your Lordship that the organization of the Intendance, to which I now return, is in harmony with that of other French military institutions.

Military supply and transport are intimately connected. Supply of an army is wholly dependent on transport. Both, therefore, are placed under one department, the "Intendance Militaire," organized expressly for their service. The Medical Department, with the exception of all that relates to the "art de guérir" and regimental hospitals, is also placed under the Intendance. The art of healing is so dependent, in the army, on the means of healing, that is, hospital material, camp equipment, medicine, and the transport of these essentials, as well as of the sick and wounded, that it was deemed advisable to place the "Administration des Hôpitaux," like the other "administrations" under the "Intendance Militaire."

It is apposite to state that, besides the direction of the "Train," about 8,000 men and 14,000 horses in number, and its parks of construction and repair, composed of 300 workmen, the Intendance has under its orders three distinct "administrations," with "troupes d'administration," who execute the various duties of the Hospital and Army Supply Service.

They are—

Firstly. The "Administration des Hôpitaux, composed of officers, non-commissioned officers, and men, who take charge of hospital material and stores, place the furniture in the hospitals, pitch and prepare the ambulance tents, attend the sick, place the wounded in the cacclets and mule-litters, maintain discipline in the hospitals, &c.

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The chief rank of officers of these troops is called "Officiers principal;" then come "Officiers comptables" of first and second class, and "Adjoints d'administration" of first and second class. The non-commissioned officers are called "Elèves d'administration" and the men "Infermiers." The latter are about 1,000 or 1,100 in number.

Secondly. "Administration du Campement et Habillement" (Camp Equipage and Clothing), of which the duties are performed by the Troops of the—

Thirdly. "Administration des subsistances" (provisions), composed of officers, non-commissioned officers, and, "ouvriers" (workmen), who perform the duties of storing, sorting, supplies of food for man and horse, fire-wood, coal, tending and slaughtering cattle, baking bread, &c. The officers and non-commissioned officers of this "administration" have the same denomination as those of the "Administration des Hôpitaux." The men are called "ouvriers" and are about 2000 in number.

The Conscripts, who are of the trades required, are drafted into the "Troupes d'administration," who are as much under military discipline as the troops of the line.

The military organization of civilians, workmen, or tradesmen, non-combatants, who supply the wants of an army, constitute the value and merit of the great system under the authority of the Intendance. At first sight, its duties appear too vast. But the union of departments performing analogous duties, in one hand, armed with discipline, enables the Intendance to work the whole system, so that its branches, instead of clashing, assist one another.

I am not prepared to say that some modification might not be made with respect to the Medical Department, which would improve their position, without diminishing the responsibility of the Intendance for the supply, transport, and discipline of the hospital, for which medical Officers are not competent, because not educated for it.

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In the time of Napoleon the First, the Supply and Transport Service of the army were performed by officers called "Commissaries de Guerre," and the army accounts were audited, and orders for payment (mandats) of the public creditors, that is the officers of the army, sellers of supply, &c., given by other officers called "Ordonnateurs." In 1817 both these Offices were united into one great department, called the "Intendance Militaire." Its duties required that it should be composed of officers of good conduct and intelligence, who had acquired sufficient military experience, and who were not too old to become versed in the system of army supply, transport, and accounts. With the view to obtain this desideratum, the Intendance was opened to officers of all "armes" who had arrived at the rank of Captain, whose age did not exceed thirty-eight years, and who should pass the best examination before a commission, presided over by a Lieutenant-General, and composed of officers of the Ministry of War and of the Intendance, which sits at Paris for the express purpose of examining the records of service and testing the qualifications of candidates for the Intendance.

Any officer whose "notes" show that he has not the steadiness necessary for the service of the Intendance is rejected at once, no matter how good an examination he may have passed.

The Intendance is well paid, and has good promotion. With the view to give it a position suited to the great importance and responsibility of its duties, an "ordonnance" constitutes it a part of the second section of the "Etat-Major-Général." The officers of the corps are highly educated, having most of them entered the army as officers, in consequence of having passed good examinations at the Military Schools, St. Cyr and the Ecole Polytechnique. They have an excellent tone, are most useful public servants, and enjoy great consideration. Under these circumstances, it is not surprising that the candidates to enter the corps are numerous.

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The officers of the Intendance are designated "Intendans," "Sous-Intendans" of first and second class, "Adjoints" of first and second class. The rank of these officers is "assimile," although junior in precedenee to that of Brigadier-General, Colonel, Lieutenant-Colonel, Major, Captain, of which ranks they wear the insignia.

In the Armée d' Orient, which is divided into corps, the Chief Intendant is called "Intendant-Général." He commands the whole Intendance, and is stationed at the "Grand Quartier-Général" of the Commander-in-Chief. An Intendant is at the head-quarters of each of the three corps — a-Sous-Intendant at that of each of the twelve divisions of Infantry, and of the two of Cavalry. The post of these officers, under fire, is with the Commander-in-Chief and Generals of Corps and Divisions. They are answerable that the Ambulance Transport is at hand to carry off the wounded, and thereby obviate the fatal evil of soldiers leaving their ranks, under fire, to carry to the rear the wounded, and they are ready to receive orders for the issue of a ration or less of spirits to the troops, when tired by a long combat.

The Intendant Général acts under the orders of the Minister of War and the Commander-in-Chief. The former assists him in France, or elsewhere, in procuring supplies and military and naval transport. In cases of necessity the Intendance obtains, through the Commander-in-Chief, the assistance of the imperial navy in transporting troops. The French ships-of-war have been very useful in conveying from the Crimea sick and wounded. The wear and tear they sustain in doing so is more than compensated by the good they do to the public service, and the experience they acquire of navigation and the sea.

The Intendant-Général, with the approbation of the Commander-in-Chief, makes what may be called his strategical plan for the positions of the companies of the "Train," aud their parks of construction and repair, of magazines for his vast

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stores of supply, of the hospitals and ambulances, of the military bakeries, and of the "troupes d'administration," who serve their different establishments.

His object is to convey supplies from the ports by the shortest lines, and, consequently, with the least possible wear and tear of transport, to the army, and the sick and wounded to the ambulances or place of embarkation.

For this purpose the Intendance has established reserve hospitals at Constantinople, a store of medicines, and "ambulances sedentaires" at Kamiesh, at the "Grand Quartier-Général," and several other points, and "ambulances volantes" with each of the twelve divisions.

The magazines of camp equipment and clothing are at Kamiesh, as well as others of provisions, wine, forage, and of wood, &c. "Magasins de reserve," containing provisions for man and horse for two or three months, are at the "Grand Quartier-Général," Kadekoi, and the 2nd Corps. There are, besides, the "Magasins de division," containing provisions and forage for twenty days.

Two bakeries are established—one at Kamiesh, the other at Kadekoi: they furnish the troops, in winter, with fresh bread every other day.

Before speaking of the distribution of the "Train" I shall have the honour to state the degree of authority which the Intendance exercises over it.

In every thing relating to transport, the authority of all grades of the Intendance over the "Train" is complete.

All recommendations for promotion, decorations, &c. in the "Train," pass through the Intendance.

In matters of instruction and interior discipline of the squadrons, the authority is with the squadron or company's officer; and, of course, when any part of the "Train" is attached to a division, the General commanding it exercises

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the same authority over it as he would over Artillery or Cavalry under his orders.

But the fact is that matters of discipline in the "Train" are so mixed up with those of the Transport Service, and the power and influence of the Intendance over the "Train" is so great and constant, that the officers of the latter are generally willing to acknowledge the complete authority of the Intendance.

The Intendants or Sous-Intendants are under the Generals commanding corps or divisions to which they belong.

But these Generals, or the Staff, cannot interfere with the Intendants in transport matters, for the performance of which they are solely responsible.

The "Train," which performs here the supply and sick transport duty, is distributed as follows:—

Eight companies, of which five, one provisional, and two auxiliary, are at Kamiesh.

Eighteen companies, of which seventeen are of the "Train," and one provisional, are at the "Grand Quartier-Général" and Kadekoi, close to Balaklava. This number includes the reserves of "Train," which, in case of attack or any emergency, can be directed on any given point.

Two companies are with the 1st, five with the 2nd, and two with the 3rd Corps.

One provisional company is in the plain of Balaklava.

Two auxiliary companies are with the French force at Eupatoria.

Two auxiliary companies of buffaloes, and two of horses, are gone to recruit at Varna.

This distribution of the French "Train" shows that it is made with reference to the ports of supply and good roads, and that it is not divided equally amongst corps and divisions. Nine companies are only allotted to the twelve divisions

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of the French army now here, whereas exactly three times that amount—twenty-seven companies—are concentrated on the good roads and line of supply, of which the two ports of supply, Kamiesh and Kalekoi (which is close to Balaklava), are the extremities, and the "Grand Quartier-Général" is the centre.

It would not be possible to give to each corps or division an equal amount of "Train," because, as it is self-evident, the corps or division near the points of supply require very little transport, whereas those at a distance from them require a great deal; the further they are off, of course, the more they require. For example, the first corps being near Kamiesh, the port of supply requires only two companies of "Train," whereas more than double that amount, five companies, are required to transport bread and other supplies from Kadekoi to the single division of 12,000 men and 1,700 horses in the valley of Baidar.

In all operations, divisions of a large army must, like those of the French army here, be at different distances from the points of supply, and consequently they cannot have an equal share of transport; if they have, the transport of divisions near the point of supply will have next to nothing to do, whilst that of the distant divisions will not only be overworked, but unable to supply those divisions.

The nearer the "Train" is to the port, the more does it save the transport of its own provisions, forage, huts, and materials; an essential consideration when 8,000 men and 14,000 horses, the number of the French "Train" here, are to be hutted and fed. This is another reason why the French, as much as possible, attach transport to supply, and not to fractions of the army, and why they have concentrated twenty-seven out of thirty-six companies as near as possible to the two seaports.

The bakeries also are established, not with the corps or divisions, but near the ports of Kamiesh and Balaklava, where

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the wood is imported, in order to save the transport of wood, of which there is a great consumption in baking. Another bakery has been set on foot near Baidar for the troops there; it is in the midst of wood.

Independently of the reasons I have adduced, French Officers, good authority, not of the "Intendance," are of opinion that it would not be desirable to make the "Train" part of the corps or divisions. They think that the power of the General officer would speedily efface that of the "Sous-Intendant," that the best commander of a corps would be an indifferent director of his "Train." Land Transport is such an universal accommodation, and at the same time is so easily destroyed, and with such difficulty restored, that too much care cannot be bestowed on maintaining its integrity. Nothing more natural than that a zealous General, anxious to see his troops in good order under arms, and to manœuvre them, should transfer certain fatigue duties to his "Train," and nothing more certain than that such an employment of it would compromise its real and only duty, which is, to insure the existence and health of the army and to enable it to advance against, or, in case of necessity, retire in honour and safety from an enemy.

In no case are the advantages of the French system of Land Transport more clearly seen than when operations take place. The Commander-in-Chief acquaints the Intendant Général with the amount of force he intends to move, the distance it will march, the nature of the country through which it is to move, whether it is likely to sustain many casualties or otherwise, &c. The Intendant Général makes his arrangements accordingly, for the transport of supply and ambulance material, and submits them to the Commander-in-Chief for his approval. If the country is mountainous he takes only light companies with the force and "ambulances volantes" (divisional ambulances), and mounted companies (with vehicles) to convey reserves of supply and of ambu-

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lance material to advantageous points in rear of the army or corps of operations. After the Commander-in-Chief has approved the transport arrangements, he takes no further trouble about them. The Intendant Général is answerable for their execution.

I have not meant, by anything I have said, that divisions should not have a small amount of transport; on the contrary, a small amount is necessary for ambulance purposes, or for any case of sudden emergency.

Besides the "Train," the French army avails itself of other means of transport when it wishes to make an operation of importance.

On such occasions each of the "armes" is ordered to carry its own provisions for a certain number of days, of which six is the maximum, for man and horse, that is, biscuit, rice, coffee, sugar, salt, and barley. The troops are in light marching order and carry their "tentes d'abri." The "Train" carries as much of the same sorts of provisions and forage as it can. No hay nor wine is carried by troops or "Train." The latter carries a little brandy for the troops; "Laviande," that is, cattle or sheep, march in rear of the troops. Horses, cattle &c., eat what hay or grass can be found on the line of march.

When the French troops marched from Old Fort they carried, in the way I describe, five day's provisions. No "Train" had been disembarked, but such Tartar carts as could be got carried provision and forage.

In Africa, the French troops have carried as many as eight day's supply. Such a load is very heavy for men and horses, but each day's consumption lightens it.

The Intendant Général informs me that the "Train" could transport six days' food for 120,000 men of all arms: that the troops could carry six days' more, that, consequently,

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120,000 French troops could, at the present moment, undertake operations for twelve days.

Each battalion of Infantry is allowed two mules to carry its chest, archives, &c.

The Officers of the Staff, Field, and General Officers, &c., are, as in all armies, allowed forage for horses, and bât animals according to their rank. The Officers of each company are allowed rations for one bât animal.

The information which the note gives respecting the failure of the native, or auxiliary companies, confirms completely the opinion which Marshal de St. Arnaud expressed in his Report (Inclosure No. 2), with respect to the bad effects of employing civil elements for military transport. The note shows that all the endeavours of the Intendance, aided by French Consuls in the Levant, has failed in obtaining faithful native drivers.

It is in vain to expect good military service from civilians attached to an army, even of their own country in the field. They prejudice discipline by their disregard of it, and they fail when they are most wanted, in the hour of danger and of great hardship. Still less can be depended on Orientals—such as the French auxiliary drivers, who are bound neither by discipline nor ties of country to the army with which they serve. They will abandon that army in a crisis, and return to their homes, or desert to the enemy.

An army which makes war in the East, in the interior, and, above all, against Russia, should have its transport as perfectly organized and disciplined as any of its other "armes." An army deprived of one of its regular "armes" can make a good fight, if it take advantage of ground; but an army without transport is lost in the interior of a Russian province, where there is nothing but wood, water, and grass, and not always that.

It is the tactics of Russian Generals to draw an enemy into their country, burning its resources, and carrying its

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inhabitants and their stock along with them. These tactics have succeeded, and they will succeed again, unless an army have an efficient transport, or be supplied, as in the Crimea, from the sea; or unless an army invading the interior of Russian provinces can reckon on supply or assistance from populations hostile to the Russian Government; as, *for instance, an army, with Theodosia for its base, and moving from Anapa by the military road along the right bank of the Kouban, on Stauropol and Ichaterinogrod, might count on aid from the warlike inhabitants of the Caucasus on their right flank, give their hand to Shamyl in Daghistan, and, with the aid of this unconquered chief, occupy the great pass of Dariel, and cut off the Russian provinces to the south of the Caucasus from Russia Proper, Omer Pasha threatening and manœuvring against Georgia, whilst another attack might be directed against the north of Russia from the Baltic.*

I venture to dwell on this important subject, because on it depends the success of armies and of the policy which they uphold. Better to have only 10,000 men with perfect transport, which insures their efficiency, than double that number with imperfect transport and all the evils which follow in its train,—an embarrassed strategy, neglected sick, and an ill-supplied soldiery.

The experience which I have acquired from nearly two years' service with the French army in the field, inclines me to think that the French system of transport is, on the whole, excellent. It is founded on the experience of long and great European wars, as well as on that of numerous campaigns in the East; it is founded on the most valuable of all experience, that which results from failures and success. The experience of European wars did not enable the French to organize a "Train," suited to the requirements of an African campaign. Marshal Bugeaud, an authority whose opinion commands universal respect, has declared that he believes that France, with all her brilliant valour and resources, might

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not, perhaps, have effected the conquest of Algeria unless she had made her " Train" so complete as to overcome the obstacles which its inhabitants opposed to French troops.

The present French " Train" attained that object, and the desideratum of Military Transport. It enabled the French army to exist and carry on war in a country which the enemy had stripped of all its resources, and to preserve their sick, wounded, and weary; for one of the duties of French ambulance litters is to carry soldiers lame or exhausted by a march; and certainly nothing tends more to keep up the spirits of soldiers than to know that, whether they are sick, wounded, or unable to march, they will never be abandoned.

So well did the French " Train" perform its duty in Africa, that on one occasion a French Prince, after a successful campaign, requested that the Officer of the " Train" should be presented to him before those of any " arme," a distinction which no one begrudged to that gallant and useful corps.

The French " Train" did in the Crimea the same good service they had done in Africa.

The light companies in front were as useful here as they had been in that country in broken and mountainous ground, whilst the mounted companies supplied the reserves and rear.

The " Train" have, during eighteen months, supplied the wants of the French army, which has gradually increased in numbers from 25,000 or 30,000 to 150,000 men, occupying an extended line of 25 or 30 miles in length. It has done so in a siege unexampled for difficulties in battles, in weather of every description, in operations in very difficult ground, and in a country destitute of resources.

The French " Train" has come out of all these trials with succcss.

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In the record of the services of the French "Train," those of the department which direct it ought to occupy a prominent place. The experience of the Crimean campaign has shown that the "Intendance" is qualified by the nature of its institution, by the talent and excellent conduct of its officers for the direction of an "arme," which is of paramount importance, because its organization is as difficult as its action is decisive; and when, as a British officer, I tell the merits of the French "Intendance" and the "Train," I ought not to forget the generous assistance which, in the depth of a most severe winter, and in difficulties of every sort, they gave last year to the sick and wounded of the British Army. General Canrobert, so negligent of his own comforts, so thoughtful for others, never refused, and often volunteered the aid of the French ambulance litters to his English allies; and no better eulogy can be passed on the French "Train" than that, whilst they succoured their own wounded they did the same good office for their ally, and at Alma and Inkerman for their enemy.

I have, &c.

(Signed) HUGH ROSE.

INCLOSURE 2.

Translation of the Minister of War's Report to the Prince President of the Republic, on the Re-organization of the Train of Military Equipages.

Paris, February 29, 1852.

MONSEIGNEUR,

The Transport Service is a modern creation; this organization of the transport necessary for the wants of an army came into existence in the midst of war, which is the best proof of its undeniable utility and of the importance of keeping it up.

Formerly, the land transport for the French army was obtained by forcible requisitions for men, horses, and carts.

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Subsequently, this service was performed by means of regular contracts, which was an advance in improvement. But the resources of the wealthiest contractors could never keep pace with the work to be done. The action of contractors was perpetually jarring with the regularity and discipline which constitute the strength of modern armies.

From so far back as 1757 the French Government were compelled to undertake the construction of carriages and harness for the companies of the "Train," who took account of and became answerable for them. The Government had also to pay the companies in advance, and to authorize, in the shape of a loan, the issue to them of rations, forage, &c. from the national magazines.

In the great war of the Republic and of the first years of the Empire, the Government were obliged to do still more. Young soldiers were placed at the disposal of the contractors, who were unable to organize militarily a sufficient number of civilians as drivers. Notwithstanding all these advantages conceded to contractors to facilitate their performance of the land transport, the desideratum could not be obtained; and the inherent evils of the system became evident. The Emperor Napoleon said, with reference to this subject, in a letter of the 6th of March 1807 :—

"Nothing is so absurd as contracts; a contractor puts into the lottery, in which he may be ruined without being to blame; or may gain a million without a cause. I shall organize Military Transport, like the Train of the Artillery Transport, which is the only progress that has been made in administration."

The Emperor lost no time in carrying out his views with respect to Military Transport (" Equipages Militaires"). The decree of the 26th March 1807 ordered the organization of the "Train" in battalions, commanded by Officers of the rank of Captain. At first only nine battalions were

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raised, each of four companies. In 1808, 1809, and 1810, four additional battalions were raised.

In 1811 a light battalion was raised, provided with mules instead of carriages.

From 1811 to 1812 the "Train" was necessarily increased in number and companies, till it consisted, at the time of the Russian campaign, of as many as twenty-two battalions, each of six companies.

In 1813, 95 companies were formed from the remains of the "Train" which returned from Russia, and a battalion was attached to the Imperial Guard. The end of this year was marked by the employment of the "Train" for the use of the ambulances; a battalion of 10 companies was formed specially for this service, and to each of the companies was attached a company of hospital attendants or nurses, "Infermiers Militaires." This creation (or formation) was the result of a painful experience acquired in war. Care of the wounded often weakened corps already thinned in battle.

The "Train," to whom this duty was entrusted, was honoured by being enabled to share the dangers of the field of battle. From that time forward the performance of this noble duty obtained for the "Train" the esteem and gratitude of all those who saw it, especially in Algeria, performing this service invariably with as much courage as self denial.

The Corps of Military Transport experienced, like the rest of the army, the effects of the vicissitudes which marked the years 1814 and 1815. Only 400 or 500 carriages (caissons) remained out of its immense material, and in 1823 the corps could not be made efficient for the opening of the Spanish campaign. Reduced in 1816, under the new name of Squadron, to two companies, the "Train" was rapidly increased to 22 brigades of pack-mules, after a vain attempt to form them by means of non-military elements.

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The successful campaign in Spain was the cause of a fresh reduction of the " Train." However, the lesson of 1823, was not without its fruits, and at least the basis of a primary organization was retained for war as well as for peace ; from the 4 companies which remained in 1824, the corps was raised, in 1830, to 8 service and 1 depôt companies by an ordonnance, which authorized also the formation of 8 reserve companies.

The " Train" was increased and diminished subsequently according to the state of the war in Africa and events in France up to the years 1850 and 1851, when 6 companies raised on account of the political events in France of 1848, and 6 " compagnies auxiliares" in Algeria, having been disbanded, the corps consisted in France of one squadron of 4 service companies, plus 4 depôt companies ; in Algeria, of 3 squadrons of 12 service companies. It appears to me Monseigneur, to be of the utmost importance to submit to your notice the succession of changes which have taken place in the " Train ;" those changes are a lesson by which it is essential that we should profit.

What is most worthy of remark is, the manner in which experience has confirmed the laudable determination of the Emperor to entrust to the " Train," as their most ennobling duty, the carrying off the wounded from the field of battle. This, of all the " Train's" duties, is the first and most important one. With a well organized "Train" a Commander-in Chief will be enabled, on the eve of a battle, to forbid his troops to quit their ranks for the purpose of taking away the wounded. In Algeria, the use of a mule with a cacolet or a litter was first adopted. By means of these ingenious equipages, hundreds of wounded, amputated, and sick soldiers, have been transported in safety to our base of operations.

Marshal Bugeaud was a warm advocate of the mule litter ; he compared the good they effected with what he had witness-

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ed in 1814 in Spain, when, in consequence of the want of transport suited to the ground, whole divisions had been obliged to leave their wounded on the field.

So strongly did Marshal Bugeaud feel the bad effect which such a neglect must produce, that he went so far as to say,—

"Perhaps the courage of our troops would not have sufficed for the conquest of Algeria, if we had not been able to save our sick and wounded from the Arabs."

Marshal Bugeaud proposed, as results of his experience in Africa,—

"That sections of the 'Train' provided in a proper proportion with cacolets and litters, should form part of each ambulance attached to a division of Infantry and Cavalry, and to each of the reserve ambulances.

"I even go so far as to say, that the divisions should only have ambulances exactly similar to those of the army of Africa, and that carriages should be attached alone to the reserves.

"I am convinced that the good effects of this new organization will meet with the same approval in Europe as it did in Algeria; that it will be adopted universally; and that a complete change will ensue in the all important system of ambulances with armies in the field."

It appears to me, Monseigneur, that the time has come to turn to account opinions of such weight; and it is for this reason that I have studied and submitted to you a new organization of Military Equipages.

The Emperor made up his mind, and the experience of a long war confirmed this conviction, that it is indispensable that armies should have a "Train" organized on an exclusively military principle.

The Restoration lost sight of this principle, and paid dearly for the oversight in 1823. If since that period the principle has not been forgotten, I may say, nevertheless, without

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fear of contradiction, that not one of the plans which have followed one another has borne the stamp of practical experience. In fact, not one of them has combined the twofold object of offering, in time of peace, sufficient resources for a war establishment; ensuring, on the other hand, when war, or any extraordinary state of affairs has ceased, the maintenance of the valuable "cadres" by "dédoublement," of which the exigencies of any emergency might be instantly provided for.

It appears to me that this object will be obtained by increasing to five the number of squadrons, but by reducing to four, one of which a depôt, the number of companies of each squadron. In this way the actual strength of the corps will not be increased. On the other hand, by giving a solid organization to the "cadres," 35 companies might be raised (without reckoning the depôts) when required, without an effort.

There would then remain, deducting the number necessary for Algeria, about 26 companies for service in Europe; that is what is required for 300,000 men.

The squadrons, instead of being organized exclusively for carriages ("conduite des voitures"), will be composed, as suggested by Marshal Bugeaud, partly of mounted companies, and partly of light companies for the service of the ambulances. All of them will be able to assist one another, because all will be recruited with young soldiers, who will have received at the depôt a common education suited to both services.

The action of command, united with that of the "Intendance Générale", will be sufficient, without having recourse to a special staff, to acquire for the establishment the useful effects which the Emperor promised himself, when he dictated the remarkable instruction of the 14th February 1812.

Finally, the manufacture or construction and keeping in repair of the material will be effected, in special parks, by means of three companies of workmen, makers of Military

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Transport, of which a Director will have the chief command as well of the establishments at home and abroad.

The features of the new organization which I have set forth are detailed, Monseigneur, in the project of a decree inclosed, which I have the honor to submit to you for your signature. They combine economy with the good of the service, and I trust that they will, consequently, obtain your entire approbation.

I have, &c.

(Signed) A. DE ST. ARNAUD.

INCLOSURE 3.

Décret portant Réorganisation du Train des Equipages Militaires.

Art. I. Le service des équipages militaires se compose de deux parties distinctes, savoir:—

Le service actif,
Le service des constructions.

Service actif.

Le service actif comprend—

I. L'enlèvement sur le champ de bataille, pendant et après le combat, des blessés et des malades hors d'état de marcher, et leur transport aux ambulances;

2. Le transport, à la suite des divisions actives, du matériel des ambulances, et, à la suite des quartiers-généraux, des reserves de toute nature;

3. Le transport, en temps de paix et en temps de guerre, du pain, ainsi que des denrées et des objets nécessaires à la nourriture et aux besoins divers du soldat, lorsque les troupes ne peuvent aller les prendre aux lieux de distribution.

Service des constructions.

Le service des constructions comprend la confection et l'

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entretien du matériel roulant et du harnachement nécessaires aux troupes des équipages.

II. Un parc principal de construction et des parcs secondaires ou des réparations, soit à l'interieur, soit à la suite des armées actives, sont affectés à la construction et à l'entretien du matériel des équipages militaires.

Trois compagnies d'ouvriers sont attachees aux parcs pour l'execution des travaux.

III. Cinq escadrons du train sout employés à la conduite des équipages militaires.

L'organisation de chaque escadron comporte, en temps de paix,—

Un état-major
Un peloton hors rang,
Trois compagnies actives,
Une compagnie de dépôt

En temps de guerre, la force de chaque escadron est portée á huit compagnies, dont une de dépôt, au moyen du dédoublement des cadres existants.

IV. Selon les besoins du service, le Ministre de la Guerre détermine le nombre des compagnies du train des équipages qui doivent être affectés à la conduite des voitures, et le nombre de celles qu'il convient d'organiser en compagnies lègéres pour la conduite des mulets d'ambulance.

Le Ministre détermine également, en temps de paix et en temps de guerre, d'après les besoins du service l'effectif, en soldats, en chevaux, ou mulets, ainsi que le nombre et l'espèce de voitures á assigner á chacune des compagnies d'ouvriers constructeurs et du train des équipages militaires.

V. Les escadrons du train des équipages sont commandés par des officiers du grade de Chef d'Escadron ; cependant l'un des escadrons peut-être commandé par un Lieutenant Colonel.

Lorsque plusieurs escadrons ou fractions d' escadrons sont réunis sur un même point, l' officier de l' arme du grade le

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plus élevé, et le plus ancien à grade égal, prend le commandement de toutes les troupes des équipages.

VI. A la tête du dépôt de chaque escadron est placé un Capitaine-Major, choisi de préférence parmi les Capitaines Commandants.

L'aptitude à cet emploi doit être reconnue par l'Intendant divisionnarie dans la circonscription duquel les candidates se trouvent placés, et par l'Inspecteur de l'arme qui propose au Ministre les sujets les plus capables et les plus méritants.

VII. Le commandement supérieur des parcs et des trois compagnies d' ouvriers est confié à un Directeur du grade de Colonel ou de Lieutenant-Colonel.

Sont appelés à concourir à cet emploi :—

I. Le Lieutenant-Colonel commandant l'un des escadrons;

2. Le Chefs d'Escadrons de l'arme proposés pour l'avancement; Les uns et les autres, s'ils proviennent des compagnies d' ouvriers;

3. A défaut de candidats de cette origine réunissant toutes les conditions voulues, les Lieutenant-Colonels ou Colonels d'Artillerie.

VIII. Il y a un sous-directeur des parcs employé au parc principal, et un autre au parc secondaire; ces officiers seront du grade de Chef d'Escadron.

IX. Les commandants des parcs de reparations sont choisis parmi les capitaines des compagnies d' ouvriers, et parmi les capitaines des compagnies du train des équipages, reconnus aptes et proposés pour cet emploi spécial.

X. Les compagnies d'ouvriers constructeurs et les escadrons du train s'administrent séparément, conformément aux prescriptions de l'Ordonnance du 10 Mai, 1844.

L'administration distincte est exercée dans toute compagnie ou fraction de compagnie, d'après les principes posés par la même ordonnance.

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Les commandants des compagnies du train sont assistes, dans les écritures et les détails relatifs à l'administration dont ils sont chargés, par un lieutenant ou sous-lieutenant de leur compagnie. Cet officier sera choisi par eux, afin que le principe de responsibilité posé par l'art. 90 de l'Ordonnance précitée ne soit en rien altéré.

La capacité du candidat proposé pour remplir prés du capitaine les fonctions d'officier de détails sera reconnue préalablement par l'Intendant divisionnaire, ou par un fonctionnaire de l'intendance délégué à cet effet.

XI. L'avancement dans le corps des équipages militaires a lieu d'après les règles tracées par l'Ordonnance des 16 Mars et 11 Janvier 1842, sauf les modifications suivantes:

Les lieutenants en premier et en second des compagnies d'ouvriers qui réunissent toutes les conditions voulues, pourront concourir indistinctement pcur les vacances de capitaines revenant aux choix.

Il en sera de même pour les lieutenants de première et de seconde classe dans les escadrons du train.

La nomination des adjutants sous-officiers sera faite dans la forme prescrite par les art. 12 et 17 de l'Ordonnance du 16 Mars, 1838.

XII. La composition du personnel de direction, les cadres des compagnies d' ouvriers, et ceux escadrons du train, tant sur le pied de paix que sur le pied de guerre, sont déterminés par les tableaux ci-annexés.

XIII. Sont rapportées toutes dispositions contraires.

XIV. Le Ministre de la Guerre est chargé de l'exécution du présent décret.

Fait au Palais des Tuileries, le 29 Fevrier, 1852.

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Tableau No. 1.

Personnel des Parcs.

	Intérieur. Parc Principal.	Intérieur. Parc secondaire ou de réparation.	Armées. Parc de réparation.
Direction Central.			
Directeur (Colonel ou Lieutenant-Colonel).	1	0	0
Adjoints ou Directeur. Capitaine.	1	0	0
Adjoints ou Directeur. Lieutenant	1	0	0
	3	0	0
Parcs.			
Commandant. Sous-Directeur (Chef d' Escadron)	1	1	0
Commandant. (Capitaine)	0	0	0
Capitaine en résidence fixe	1	1	1
Adjoint, faisant fonctions d' officier payeur (Lieutenant)	1	1	0
Officier de santé (Chirurgien aide-major)	1	0	0
Professeur de mathematiques et de dessin.	1	0	0
Total...	5	3	1
Gardes de première classe	1	1	1
Gardes de seconde et de troisième classe	4	3	2*
Chefs ouvriers d'état	1	1	1
Sous chefs ouvriers d'état	4	2	1
Ouvriers d'état	6	3	2
Portier-consigne	1	1	0
Aide-portier.	1	0	0
Total...	18	11	7

* Ce nombre pourra être porté à 3, si le service l'exige.

Tableau No. 2.

Compagnie d' Ouvriers Constructeurs.

	Pied. de Paix	Pied. de Guerre.
Capitaine en premier	1	1
Capitaine en second	1	1
Lieutenants en premier	2	2
Lieutenants en second	2	2
Total des officiers...	6	6

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TABLEAU No. 2—(*continued.*)

	Pied.	
	de Paix.	de Guerre.
Sergent-Major	1	1
Sergents	8	8
Fourrier	1	1
Caporaux	8	8
Maîtres-ouvriers	8	8
Clairons	2	2
Enfants de troupe	2	2
Total...	30	30

Le Ministre détermine, en temps de paix et en temps de guerre, d'après les besoins du service, l'effectif en soldats des compagnies, d'ouvriers.

Les soldats sont de trois classes, dont le maximum est fixé ainsi qu'il suit :

Première classe, un quart de l'effectif.
Seconde „ „ „
Troisième „ moitié „

TABLEAU No. 3.

Escadron du Train des Equipages militaires.

ETAT-MAJOR.	Pied.			
	de Paix.		de Guerre.	
	Hommes.	Chevaux.	Hommes.	Chevaux.
Chef d'Escadron (un Lieutenaut-Colonel pourra commander l'un des escadrons)	1	2	1	3
Capitaine-major	1	1	1	3
Capitaine instructeur*	1	1	1	3
Trésorier (Capitaine ou Lieutenant)	1	1	1	2
Adjoint an Trésorier (sous-Lieutenant)	1	1	1	2
Officier d'habillement et d'armement (Capitaine ou Lieutenant)	1	1	1	2
Chirurgien aide-major	1	1	2	2
Vétérinaire de première classe	1	1	1	1
	8	9	9	18
Brigadier-trompette (un Maréchal des logis trompette pourra être attaché à l'un des escadrons)	1	1	1	1

* Sera également chargé des fonctions de Capitaine Adjudant-major,

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Tableau No. 4.

Escadron du Train des Equipages.

	Maréchal des logis chef.	Maréchal des logis.	Maître ouvrier.	Brigadier élève fourrier.	Brigadier.	Soldat.	Total.
Peloton hors rang—							
Service du peloton … … … … … … …	1	1	0	1	2	0	5
Secrétaires — du Commandant… … … … …	0	0	0	0	0	1	1
Secrétaires — du Capitaine-major… … … …	0	0	0	0	0	1	1
Secrétaires — du Trésorier … … … … …	0	1	0	0	1	2	4
Secrétaires — de l' Officier d' habillement… …	0	1	0	0	1	1	3
Atelier — Armuriers-éperonniers … …	0	0	1	0	0	2	3
Atelier — Selliers-bourreliers… … … …	0	0	1	0	1	3	5
Atelier — Tailleurs … … … … … …	0	0	1	0	1	10	12
Atelier — Bottiers … … … … … …	0	0	1	0	1	8	10
Enfants de troupe … … … … … … … …	0	0	0	0	0	1	1
Total…	1	3	4	1	7	29	45

Tableau No. 5.

Escadron du Train des Equipages.

	Compagnie Active ou de Depôt.			
	Pied de Paix.		Pied de Guerre.	
	Hommes.	Chevaux.	Hommes.	Chevaux.
Capitaine commandant … … … … … … …	1	2	1	3
Capitaine en second … … … … … …	1	2		
Lieutenants de première et de seconde class… …	3	3	3	6
Sous-lieutenants … … … … … … … …	3	3		
Vétérinaires de seconde classe… … … … …	1	1	1	1
Total…	9	11	5	10

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TABLEAU No. 5.—(*Continued.*)

	Compagnie Active ou de Depôt			
	Pied de Paix.		Pied de Guerre.	
	Hommes.	Chevaux.	Hommes.	Chevaux.
Adjudant sous-officier	1	1	1	1
Maréchal des logis chef	1	1	1	1
Maréchaux des logis...	10	10	8	8
Fourrier	1	1	1	1
Brigadier élève fourrier	1	1	1	1
Brigadiers	20	20	16	16
Maréchaux ferrants	3	0	3	0
Selliers, Bourreliers, Bottiers	6	0	6	0
Ouvriers en bois et en fer...	10	0	10	0
Trompettes	4	4	4	4
Enfants de troupe	2	0	2	0
Total...	59	38	53	32

Le Ministre réglera, quant aux compagnies dont se composera chaque escadron sur le pied de paix ou sur le pied de guerre, le nombre de celles qui seront montées et le nombre de celles qui serviront comme compagnies légères.

Lorsqu'il y aura lieu de dédoubler le cadre d'une compagnie active sur le pied de paix pour l' organization de deux compagnies de guerre, le chef de corps désignera les officiers à repartir entre celles-ci ; il fera en sorte qu' aucune d'elles ne comprenne deux lieutenants de première classe.

Chaque compagnie de guerre comptera 1 capitaine, 3 lieutenants ou sous-lieutenants, et 1 adjudant et sous-officier.

On procédera comme il a été dit ci-dessus pour les sous-officiers, brigadiers, ouvriers et trompettes, après avoir porté par une promotion les titulaires des divers emplois au nombre que comportent les cadres de deux compagnies de guerre ; et on fera ensuite, entre les deux compagnies, une répartition égale des militaires de chaque grade.

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On réservera pour le dépôt les officiers et les sous-officiers les moins aptes à faire campagne.

Le tiers des soldats de chaque compagnie active sera de première classe.

Paris le 29 Fevrier 1852.

Inclosure 4.

Note sur les Transports de l' Armée Française d' Orient.

Dans les conditions actuelles de l' organization militaire en France, une armée en campagne admet nécessairement dans sa composition trois corps, ou fractions de corps, spécialement affectés au transport des denrées ou matières qu' elle doit trainer à sa suite,—le Train de l' Artillerie, le Train du Génie, et le Train des Equipages Militaires.

Train d' Artillerie.

Avec les moyens dont elle dispose, l' Artillerie assure le transport des munitions de l' armée, des siennes propres, et du matériel spécial au service de cette arme.

Train du Génie.

Les compagnies de Sapeurs Conducteurs exécutent un service analogue pour le corps du génie.

Enfin, le train des Equipages Militaires, qui est le véritable train de l' armée, est chargé d'assurer—

1. L'enlèvement sur le champ de bataille, pendant et après le combat, et le transport aux ambulances des blessés et des malades.

2. Le transport du matériel des ambulances à la suite des divisions actives, et le transport du matériel des subsistances, des hôpitaux, de l' habillement, et du campement à la suite des quartiers généraux.

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3. Le transport du pain et des denrées nécessaires à la nourriture des hommes et des chevaux.

4. Le transport du matériel de la Trésorerie et des Postes.

5. Le transport des archives des Etats-Majors et de l'Intendance Militaire.

Bien qu'ils diffèrent par leur constitution, et la nature de leur service spécial, le Train de l'Artillerie, du Génie, et celui des Equipages Militaires présentent de nombreuses analogies en ce qui concerne leur organisation; ils sont d' ailleurs assez fréquemment appelés à se prêter un mutuel secours.

Nous ne nous occuperons donc que du dernier corps, qui par la variété et l'immensité des besoins auxquels il doit pouvoir acquiert une importance qui peut être décisive dans les operations d'une compagne.

D'après les réglements actuellement en vigueur, le personnel des Equipages Militaires de l' Armée Française comprend—

1.—Un Etat-Major des Parcs.

2.—Six Escadrons du Train, non compris celui de la Garde Impériale.

3.—Cinq Compagnies d'Ouvriers Constructeurs.

L' Etat-Major des Parcs composé d' officiers supérieurs et subalternes, de gardes et ouvriers d'état, est placé à la tête des établissements permanents existant en France, et de ceux que le Ministre crée à la suite des armées; il dirige la construction et l'entretien du matériel de transport, la confection, et l' entretien du harnachement nécessaire aux troupes des Equipages Militaires.

Les compagnies d'Ouvriers Constructeurs, composées d'ouvriers en fer, en bois, courreliers, &c. &c., sont réparties dans les parcs de l' intérieur, ou des armées, pour y

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exécuter, les divers travaux de confection, ou de réparation du matériel.

Un parc de ce genre, comprenant deux établissements, l'un à Constantinople l' autre à Kamiesh a éte formée pour les besoins de l' armèe d' Orient. Le premier reçoit le matériel de France, et l' expédie sur le parc de Kamiesh, achête les matières premières et confectionne, enfin conserve tous less approvisionnements de réserve qui ne pourrraient être convenablement emmagasines en Crimée. Le second entretient et répare l'enorme matériel de toute nature en service à l'armée.

Les escadrons du train, qui sout spécialement chargés de la conduite des equipages, s'administrent séparément.

L'organisation de chaque escadron en temps de paix comporte :—

Un Etat-Major.
Un Peloton hors-rang.
Trois compagnies actives.
Une compagnie de dèpôt.

L'Etat-Major comprend :—

Un Officier Supérieur Commandant l'Escadron.
Un Capitaine-Major.
Un Capitaine Instructeur.
Un Trésorier et un Adjoint au Trésorier.
Un Officier d'habillement.
Un Chirurgien aide-Major.
Un Vétérinaire et un Brigadier Trompette.

Le Peloton hors-rang comprend des sous officiers, des Secretaires, des Ouvriers Armuriers, Selliers, Tailleurs, Bottiers, et des enfants de troupe.

En passant de pied de paix au pied de guerre, ces cadres ne subissent pour ainsi dire aucune modification.

En temps de guerre, la force de chaque escadron est portée à huit compagnies, dont une de Dépôt au moyen du dé-

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doublement des cadres existants, Le cadres d'une compagnie active sur le pied de paix et sur le pied de guerre est indiqué au tableau ci-dessous :—

	Compagnie Active ou de Depôt.			
	Pied de Paix.		Pied de Guerre.	
	Hommes.	Chevaux.	Hommes.	Chevaux.
Capitaine commandant	1	2	1	5
Capitaine en seconde	1	2		
Lieutenants de première ou de seconde class... ...	3	3	3	6
Sous-lieutenants	3	3		
Vétérinaires de seconde classe...	1	1	1	1
Total...	9	11	5	10
Adjudant sous-officier	1	1	1	1
Maréchal des logis chef	1	1	1	1
Maréchaux des logis...	10	10	8	8
Fourrier	1	1	1	1
Brigadier élève fourrier	1	1	1	1
Brigadiers	20	20	16	16
Maréchaux ferrants	3	0	3	0
Selliers, Bourreliers, Bottiers	6	0	6	0
Ouvriers en bois et en fer...	10	0	10	0
Trompettes	4	4	4	4
Enfants de troupe	2	0	2	0
Total...	59	38	53	32

Entre autres mérites, cette organisation a celui d'être faite en vue des besoins de l'état de guerre, et de prevoir l'augmentation prompte et facile, sans affailblissement trop sensible des cadres, des ressources que le Train des Equipages est appelé a fournir.

Les compagnies du train sont montées ou légères. Le Ministre de la Guerre détermine, selon les besoins, l'importance et le nature du service, le nombre des compagnies destinées à la conduite des voitures, et le nombre de celles qu'il convient d' organiser en compagnies légères, pour la conduite des mulets d' ambulance.

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Il détermine également l' effectif en hommes de troupe, en chevaux, ou mulets, ainsi que le nombre et l' espèce des voitures à affecter à chaque compagnie montée.

Dans les conditions ordinaires, ces effectifs varient de 200 à 250 cavaliers, et de 300 à 350 animaux.

Les cavaliers des compagnies montées portent un habit à plastron, le pantalon à fausses bottes, et le manteau du modèle génréal en usage dans la cavalerie. Ils sont armés du sabre, donné aux hommes montés de l'Artillerie, du mousqueton et du pistolet.

L' uniforme du soldat du compagnie légère doit être approprié à un service de fantassin ; il se compose d' un cabau assez court, du pantalon et usage dans les troupes d' Infanterie, et de souliers avec guêtres en cuir ou en toile. Son armement se réduit à un mousqueton avec sa bayonette.

Les compagnies légères sont spécialment affectées au service des ambulances, et au transport des malades ou blessés. Leur matériel se compose de cacolets ou de litières, dans une proportion variable, selon les besoins.

Chaque soldat conduit deux mulets de cacolets, ou un mulet de litières. Ces compagnies sont encore employées au transport des denrées, lorsque leurs animaux restent disponibles, ou lorsqu'il est nécessaire d' approvisionner quelques points, dont l'acces est impossible aux voitures.

Le matériel des compagnies montées comprend aujourd' hui trois sortes de voitures, qui sont, le caisson nouveau modèle de 1,200 rations de pain, le charriot à hautes ou basses ridelles, et la forge.

Le caisson qui devrait être exclusivement réservé au transport du pain rationné, est suspendu, d'un tournant facile,éet fermé à sa partie supérieure par un berceau recouvert en toile cirée. Son chargement est difficile, en raison de l'élévation de la caisse, divisée en deux compartiments inégaux,

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par un grand vide, ménagé pour laisser un passage aux roues de devant. Cette separation, qui ajoute beaucoup à la solidité de la voiture, empêche souvent d'en compléter la charge, quand elle doit être formée de denrées en matériel présentant un foible poids sous un grand volume. Le caisson est employé au transport du matériel des ambulances, et remplace advantageusement l'ancien caisson dit d'ambulance, qui était exclusivement affecté à ce service.

Le charriot dont le corps est fixé à l'avant train par une cheville ouvrière, a un tournant moins facile que le caisson, mais il présente les plus grandes commodités pour le transport des denrées ou de matèriel de toute nature. Son chargement est du reste parfaitément abrite par une bâche mobile.

L'expérience faite sur ces deux voitures, depuis pres de quinze mois à l'armée d'Orient a fait accorder, par tous les hommes pratiques et compétents, une ìn contestable supériorité au charriot sur le caisson. En résumé, le charriot doit être considéré comme une excellente voiture pour le service de campagne.

Chaque compagnie montée est pourvu d' objets de rechange, d'outils et autres objets, divers nécessaires à l'entretien, at aux réparations courantes des voitures.

Toutes les voitures sont attelées de quatre chevaux ou mulets et conduites par deux soldats montés.

Le harnachement et la ferrure sont entretenus par des ouvriers bourreliers et maréchaux, qui sont chargés de se pourvoir des matières nècessaires, et qui sont remboursês de leurs avances, on moyen d'une allocation, décomptée d'apres le nombre de journées de présence des animaux, qui ont figuré à l'effectif de la compagnie.

Le Train des Equipages est placé, pour l'accomplissement de son service normal, tel qu'il a été défini au commencement de cette note, sous les ordres directs des Intendants et Sous-Intendants Militaires, qui sont chargés d'en assurer,

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et d'en surveiller l'exécution. Il reléve de l'autorité militaire pour tout ce qui concerne la tenue, la discipline, et l'instruction.

Les compagnies du Train organisées équipagées et armées, comme nous venons de l'indiquer, trés sommairement, recrutées d'ailleurs avec des hommes vigoureux, qu' un service incessant et pénible endurait encore à la fatigue, se plient à toutes les exigeances, que peut faire nâitre l'état de guerre, et rendent d'eminents services, que les autres corps de l'armée se plaisent à reconnaître. On peut se prononcer avec assurance à ce sujet, car la constitution actuelle du Train des Equipages Militaires éprouvée dans nos guerres d'Afrique et à l'armée d'Orient est aujoud' hui jugée par l'expérience.

Des renforts importants en hommes, animaux de trait, et de bât, et en matériel du Train des Equipages furent envoyés, au commencement de l'année 1855 à l'armée Française de Crimée par les soins du Ministre de la Guerre, mais, si considérable que soient les moyens de Transport dont peut disposer une armée active, ils sont toujours insuffisants, et il est indispensable de les augmenter, en empruntant une partie de leurs ressources aux contrées qui servent de théâtre á la guerre ou á celles qui les avoisinents. La portion de la Crimée occupée par les forces des Puissances alliées, ne pouvant rien fournir sous ce rapport, l'administration Française se mit en mesure, des les premiers mois de l'année, et alors que les éventualités semblaient annoncer une campagne active, de réunir tous les moyens nécessaires à l'aide d'importants achats effectués sur le littoral de la Mer Noire, dans les places de la Turquie d'Europe et d'Asie. Des chevaux et mulets des bœufs de trait, des buffles, des arabas, des voitures Maltaises, et des effets de harnachement furent réunis en grand nombre, et amenés en Crimée.

Ces moyens furent augmentés par des expéditions importantes de matériel, faites dans les divers ports de France. Aux voitures Maltaises, vinrents' ajouter des voitures Mar-

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seillaises, achetées dans le midi, et des voitures légères fabriquées à Paris.

Pour utiliser ces précieuses resources, un projet d'organisation de compagnies auxiliaires du Train fut proposé au Général Commandant-en-chef l'armèe d'Orient, et approuvé successivement par lui et par le Ministre. Il avait pour objet la création de dix compagnies, composées les unes de chevaux ou mulets de bât ; les autres de Maltaises on d'arabas, avec des conducteurs Turcs ou Tatars, et des cadres fournis par le Train des Equipages Militaires. Le nombre de ces compagnies devait être augmenté au fur et à mesure des besoins.

La composition d'une de ces compagnies auxiliaire est la suivante :—

1	Sous Lieutenant ou Adjudant......................	monté.
1	Interprête..	„
1	Maréchal des Logis faisant fonctions d'adjudant.	„
1	Brigadier Fourrier faisant fonctions de Maréchal des Logis Chef..................................	„
4	Brigadiers faisant fonctions de Maréchaux des Logis..	„
1	Trompette...	„
8	Premiers soldats faisant fonctions de Brigadier..	„
4	Deuxièmes soldats.	
4	Chefs Indigènes.	
8	Sous-Chefs Indigènes.	
250	Conducteurs Indigènes.	
500	Chevaux ou mulets de bât, ou.	
250	Voitures attelées, chacune de 2 bœufs ou buffles.	

Ces compagnies placées sous les ordres de l'officier supérieur commandant les troupes du Train des Equipages en Crimée, ont été annexées chacune à une compagnie principale, qui a fourni le cadre et pourvu à tous les besoins. La compagnie auxiliaire a pris le numéro de la compagnie mère, de laquelle elle dépend pour tout ce qui concerne l'administration, la discipline, et l'éxecution du service.

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Aux termes de l'arrêté d'organisation, les officiers, sous-officiers, et soldats detachés dans les compagnies auxiliaires continuent à percevoir au titre de la compagnie à laquelle ils appartiennent leur solde et les diverses prestations qui leur sont dues.

Ils reçoivent eu outre sur les fonds des transports généraux une gratification fixée de la manière suivante, savoir :—

Sous-Lieutenant ou Adjudant Commandant.......	3f.	00c.	par jour.
Maréchal des Logis faisant fonctions d'Adjudant..	1	20	„
Brigadier Fourrier..................................	1	00	„
Brigadier faisant fonctions de Maréchal des Logis.	0	40	„
Premier soldat faisant fonctions de Brigadier......	0	35	„

Les indigènes, sauf les stipulations particulières résultant de leur acte d'engagement, ont une solde fixée comme ci-aprés :—

Interprête.........................	5f.	00	par jour.
Chef Indigène........................	3	00	„
Sous-Chef Indigène...............	2	50	„
Conducteur	2	00	„

Il leur est accordé en sus, par journée de présence, une ration de pain ou de biscuit, une ration de viande fraiche, chaque fois qu'il en est distribué à l'armée, une ration de riz, une ration de sel, et une ration de sucre et café- Quand il n'est pas donné de viande fraiche, il est alloué en remplacement une seconde ration de riz,

Celles sont les bases sur lesquelles furent organisées les compagnies destinées à compléter les moyens de transport, dont l'armée Française avait besoin pour se porter en avant. Leur nombre fut successivement porté à 17, parmi lesquelles on comptait :—

Deux compagnies de voitures Maltaises,
Trois compagnies d'arabas attelés de bœufs,
Trois compagnies d'arabas attelés de buffles,

enfin neuf de chevaux et mulets de bât.

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Le mois de Juillet était arrivé, les compagnies auxiliaires renfermaient en animaux et en matériel, au dela des ressources qui leur étalent nécessaires, et malgré tous ses efforts l'administration ne pouvait leur fournir un nombre suffisant de conducteurs indigènes.

Les ordres les plus pressants et les plus explicites avaient, été donnés, pour opérer le recrutement sur une large échelle à Eupatorie, à Constantinople, dans les autres places de la Turquie, et plus tard en Epire et en Syrie. Malgré l'assistance du Gouvernement Ottoman, et l'appui que les Pachas prétèrent généralement aux officiers Français, aupres des populations, les tentatives d'enrolement ne produisirent que des résultats nuls ou peu satisfaisants. La désertion au contraire fit de rapides progrès parmi les conducteurs déjà incorporés, et le nombre eu diminua rapidement.

Afin d'arrêter le développement du mal, le Maréchal consentit à augmenter la solde des indigènes, et à la porter à—

Pour les Chefs............	3f.	50c	par jour.
Pour les Sous-Chef......	3	00	,,
Pour les Conducteurs....	2	70	,,

Cette mesure ne fût pas plus que toutes les autres couronnée de succés. Le recrutement continué avec activité sur tout les points, ne parvenait plus à combler les vides, car les conducteurs enrôlés à grands frais à de longues distances, restaient encore dans nos compagnies moins longtemps que les Tatars de la Crimée, L'approche de la mauvaise saison augmentait le nombre des deserteurs, et les indigènes restes fidèles à leur engagement ne devalent pas inspirer une grande confiance. Il faut bien le dire du reste, ces hommes d'un caractère insouciant et de mœurs paresseuses, dont l'apathie n'est reveillée par aucun sentiment génereux. sont incapables de remplir les pénibles devoirs d'un service militaire en campagne. L' Intendant Général de l'armée comprit, qu'il était temps de porter remède à ce facheux état de choses, et il arrêta avec décision un ensemble de mesures propres à assu-

rer la conservation des précieux moyens qu'il avait réunis pour les besoins de l'armée. Dés le mois de Septembre, il proposa et obtint du Maréchal Commandant-en-Chef, l'organisation de deux nouvelles compagnies auxiliares dans lesquelles les indigènes étaient remplacés par des conducteurs Français. Ces deux compagnies pourvues d'un bon matériel (200 voitures Marseillaises et 50 Maltaises par compagnie) devaient rendre d'excellents services, Il demande en même temps au Ministre de la Guerre 2,000 hommes du Train, et fit approuver par le Maréchal, le passage dans le corps des Equipages Militaires, de 600 hommes d'Infanterie environ prèlevés dans tous les régiments de l'armée d'Orient. Mais en remplaçant les indigénes par des cavaliers du Train, il était nécessaire de mettre en rapport avec la nouvelle composition des compagnies, les dispositions de l' arrète d'organisation, approuvé au printemps par le Général-en-chef et le Ministre. A la place de l'interprête, des Chefs et Sous-chefs indigènes, qui exerçaient, une grande influence sur les conducteurs, indigènes, aussi, il ètait indispensable de mettre un nombre suffisant des Sous-officiers et Brigadiers du Train, susceptibles par l'autorité du grade, dont ils seraient pourvus, de maintenir convenablement, la discipline dans les compagnies, assujetties à un service pénible, et dont l'effectif devait être élevé relativement surtout à la constitution de leur ordre.

Un arrête d'organisation approuvé par le Maréchal, fixa d'après ces considérations, de la manière suivante la composition des nouvelles compagnies dites provisoires.

Un Lieutenant ou sous Lieutenant du Train détaché	2	chevaux
Un Adjudant monté...	1	„
4 Maréchaux des Logis	4	„
1 Maréchal des Logis Fourrier	1	„
8 Brigadiers...	8	„
1 Trompette	1	„
2 Maréchaux Ferrants	1	„
2 Bourreliers	1	„

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Compagnie Montée.

260 Cavaliers du Train.
250 Voitures Marseillaises ou autres.
500 Animaux de Train.

Compagnie Legère.

170 Cavaliers. du Train.
400 Animaux de bât.

Comme les compagnies auxiliares, ces compagnies sont annexées à celles du Train des Equipages, et en prennent les numeros. Le Commandant de chaque compagnie annexe relève du Capitaine de la compagnie principale pour tout ce qui concerne l'administration et la discipline.

Les officiers, sous-officiers, brigadiers, et cavaliers des compagnies provisoires y sont seulement détachés pour les besoins, du service. Ils continuent à recevoir au titre de leur compagnie principale les prestations en deniers et en nature, auxquelles ils ont droit d'après leur grade effectif. Enfin les Commandants des compagnies provisoires ne sont pas remplacés dans leur compagnie, et jouissent seuls, sur les fonds des transports généraux, d'une indemnité de trois francs par jour, pour frais de bureau et autres dépenses accessoires.

C'est d'après ces bases nouvelles qu'a été opérée la réorganisation des transports auxiliaires de l'armée d'Orient. Les compagnies composées d'indigènes ont été licenciées, au fur et à mesure de l'arrivée des soldats du train destinés aux compagnies provisoires, dont le nombre s'élève déjà à sept, parmi lesquelles on compte—

2 Compagnies de voitures Marseillaises.
2 Compagnies de voitures Maltaises.
3 Compagnies de chevaux et mulets de bât.

Afin d'en augmenter le nombre le Ministre de la Guerre réunit dans les dépôts des escadrons en France des renforts d'hommes importants. Si les besoins l'exigent on pourra porter le chiffre total des compagnies de cette nature à 13 ou

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14, formant par leur réunion un excellent corps d'Equipages Militaires, dont la solidité est augmentée chaque jour, par les fatigues d'un pénible service.

Les compagnies d'arabas attelés de bœufs et de buffles, resteront selon toute apparence composées d'indigènes ; il sera possible dans des limites aussi restreintes d'en assurer le recrutement. Condamnées d'ailleurs par leur matériel défectueux à servir sur les derrières de l'armée, leur organisation moins complète que celle des compagnies provisoires sera sans inconvenients graves, Mais, sans les compter autrement que comme des transports, propres au pays, et d'une importance très secondaire, l'armée Française disposant d'un grand nombre de compagnies régulières et provisoires du Train des Equipages susceptibles par leur composition de la suivre partout où sera le théâtre de la guerre doit être considérée comme pourvue de moyens de transport tels que peu d'armées en auront eu de meilleurs et de plus considérables.

Sévastopol, le 18 *Decembre,* 1855.

INCLOSURE 5.

NOTE pour M. le Général Rose, sur l'organisation des approvisionnements des Bouches à Feu, et des Armes portatives, et sur les Moyens de Passage des Rivières.

SEVASTOPOL, LE 7 JANVIER, 1856.

Chaque batterie divisionaire d'Infanterie transporte avec elle—

12 Caissons à munitions d' Artillerie, soit 200 coups par pièce.

6 Caissons à munitions d' Infanterie soit 138,600 cartouches a balles sphèriques.

Chaque batterie de Cavalerie transporte avec elle.

12 Caissons à munitions d' Artilleries, soit 200 Coups par pièce.

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2 Caissons à munitions d' Infanterie soit, 46,000 cartouches à balles sphèriques.

Chaque batterie de la reserve générale d' Artillerie transporte avec elle—

12 Caissons à munitions d' Artillerie, soit 200 coups par pièce.

2 Caissons à munitions d' Infanterie, soit 46,200 cartouches à balles sphèriques.

La parc mobile de reserve de chaque corps d'armée est approvisionné à cent coups par pièce du corps d'armée et à 15 cartouches à balles sphèriques par homme. Le nombre de caissons est déterminé par la considération qu'un caisson á munition d'Artillerie contient 78 coups, et qu'un caisson á munition d'Infanterie contient 23,100 cartouches à balles sphèriques.

La partie mobile du grand parc de compagne est approvisionée à cent coups par pièce de corps d'armée, et à deux cent coups par pièce de la reserve générale d'Artillerie, et à 20 cartouches à balles pour chaque homme d'Infanterie du corps d'armée.

La reste des approvisionnements est dèterminé, suivant les circonstances, par les instructions de son Excellence le Maréchal Commandant-en-chef, et il se trouve à la partie fixe du grand parc du campagne, savoir 1*f*. 5*c*. ou 1*f*. 6*c*. dans des voitures susceptibles d'étre attelées, et 4*f*. 5*c*. ou 5*f*. 6*c*. dans des magasins à terre, ou des magasins flottants.

Le matériel des ponts mobiles consiste, en deux ponts de chevalets à la Birago, pour le passage du matériel de campagne sur des cours d'eau de 35 à 40 mêtres de largeur. Chacun de ces ponts exige pour son transport 10 voitures attelées de 6 chevaux.

Un pont de chevalets ordinaire à chapeau fixe, pour le passage du gros matériel du siège sur des cours d'eau de 35

à 40 mêtres de largeur: il exige pour son transport 13 voitures attelées à 6 chevaux.

Le Général commandant l'Artillerie de l'Armée.
Par son ordre,
Le Colonel Chef d'Etat—Major.
C. Auger.

Inclosure 6.

Extract of a Note by General Frossard.

Les Gardes du Génie sont chargés en France de vieller à la conservation du Domaine Militaire, et d'aider les officiers pour la surveillance des travaux de fortification et de bâtiments. En campagne, on en emploie un certain nombre pour la surveillance des parcs du génie, la comptabilité des troupes. Chaque regiment du génie est composé de 2 bataillons comprenant chacun une compagnie de Mineurs, et sept compagnies de Sapeurs, total seize compagnies par régiment, plus une compagnie de Sapeurs conducteurs, qui a des chevaux, et conduit dans ces voitures le matériel du génie.

L'effectif de chaque compagnie aux armées (Mineurs ou Sappeurs) et de 4 officiers et 150 hommes du troupe.

A chaque division Infanterie aux armées est attachée une compagnie de sapeurs, qui méne avec elle une prolonge chargée d'outils en caisses, et des mulets de bàt portant aussi des outils, le nombre de ces mulets varie survant le besoin et la nature du terrain sur lequel on opère.

Il y a en outre, un certain nombre de compagnies de Sapeurs ou de Mineurs qui restant au Quartier-Général de l'armée ou du corps d'armée, pour former la réserve du génie.

Enfin, independamment des prolonges et des caisses d'outils que les compagnies ont avec elles, il y au Quartier-Général de l'armée un parc du génie, composé de plus ou moins de voitures, attelées par une compagnie de Sapeurs conducteurs; ce qui portent tous les outils et le matériel du siège, &c.

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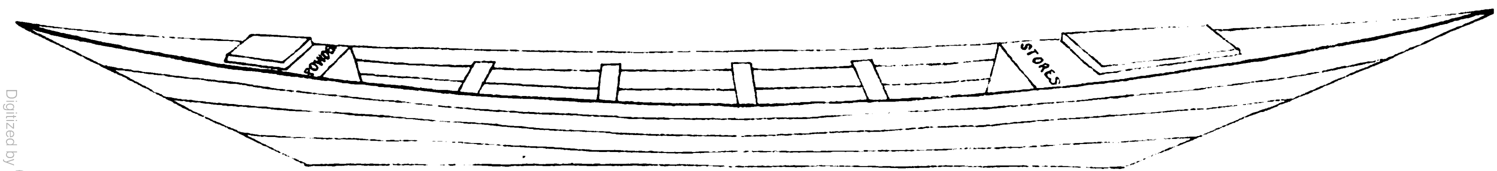
Miscellaneous.

Metallic Army Bateau.



Madras Art^y. Depôt lith^d.

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On Military Floating Metallic Waggons extracted from the Phamphlet "On metallic Boats and Floating Waggons for Naval and Military Service," &c. by Major Vincent Eyre, F. R. G. S. Bengal Artillery.

34. I WILL now pass on to another branch of the present Lecture, scarcely less important in a *military*, than I trust I have already proved the former to be in a *naval* point of view; and as such it may, therefore, be considered as falling more within my legitimate scope, as a member of the military profession.

35. The safe and easy transit of armies across swollen streams and unfordable rivers, has been acknowledged by all military writers to be one of the most formidable dfficulties in war; hence it may be fairly assumed that whatever tends to facilitate that operation by the simplest and readiest means, is justly entitled to a most attentive consideration, and I unhesitatingly point to the the models now before you, as offering the very best practical solution of the problem that has yet been produced; and I am happy to find myself supported in that opinion by several most distinguished officers of the army, who, from their very great practical experience in such matters, are entitled to speak with authority upon them. Some of those to whom I allude are here present this day, and having themselves had ocular demonstration of the capabilities of the inventicn, will perhaps be kind enough, at the conclusion of the Lecture, to favour this meeting with their views, since any remarks fron such a source cannot fail to be valuable.

36. Here is a model representing a military metallic road waggon, of the pattern now in use with the United States army; the part comprising the body being made, as you will readily perceive, on the same principle as the metallic boat just described. But to go into a minute detail of the con-

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struction might be tedious. It may suffice briefly to state that the bodies, being composed of the same corrugated metal as the boats already described, partake of the same durable and indestructible qualities; and whereas an ordinary military waggon, such as those at present in use with our army, is useful only for the purposes of land carriage, the metallic waggon unites in itself, either singly or by combination, the qualities of an ammunition or store carriage, a *pontoon*, a *row-boat*, a *raft for the heaviest artillery*, and, finally, a *bridge* for crossing the whole *matériel* of an army over deep and otherwise impassable rivers. These various qualities have been well exemplified in the lithographic drawing on the wall.* The nearest figure of all represents the waggon body set free from the running gear, and used as an ordinary boat. Next to that floats a large raft, composed of four waggon bodies united compactly together, and covered over by a platform, on which rests securely an ordinary field gun. This is a simple and most invaluable mode of applying the invention, for the movements of troops are often impeded by the difficulty attendant on the rapid transfer of artillery from from bank to bank, on reaching an unfordable stream; but guns accompanied by waggons of this description, are in a position to solve that difficulty for themselves with the greatest ease and rapidity. We next perceive a complete waggon filled with troops, drawn across the stream by some soldiers stationed on the opposite bank. These men are supposed to have established a communication, in the first place, by means of small canoes, formed of two feeding troughs united together, and conveying a man with a rope. Next, beyond, are some waggons drawn by horses, and filled with troops and baggage; on reaching the bank of the river, the horses plunge boldly in, drawing behind them their precious freight, without any delay being incurred to unload or to secure the baggage from wet. The metallic body is perfectly water-

* See Plate 50.

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tight, aud the opposite bank is reached without any damage being incurred. Last of all, in the distance, we see an excellent *pontoon bridge* formed by a number of these waggon bodies arranged side by side, and covered over with planks in the ordinary mode. By this means a whole army may pass from bank to bank in a very few hours, without being encumbered with a lumbering pontoon train, or delayed while boats are collected from distant points. On the dry bank we perceive the running gear of the waggons divested of their bodies, while the latter are serving the purpose of pontoons. This completes the picture, which was very recently drawn by an artist in Paris, by desise of the Emperor Napoleon. For transport across the seas, these metallic waggon bodies, being made in two pieces, admit of being packed closely together, one within the other, thus economising space.

37. On turning my attention to this subject in July last, so convinced was I of the very great practical utility of the invention, and of its great importance in a military point of view, that I determined to bring it to the notice ef the India House and the War Office authorities, as soon as practicable after my arrival in England; and I went so far as to indulge a hope that, if approved by the War Office, it might yet be applied to some immediate use during the war we were then waging with Russia.

38. With this view I obtained a full-sized waggon from the manufactory in New York, and, soon after its arrival, in September last, it was subjected to some highly interesting experiments, in the presence of two most distinguished officers of the Bengal Army, Lieut.-General Sir G. Pollock and Colonel Sir Frederic Abbott, the scene of operations being a piece of ornamental water, called the "Black Sea of Wandsworth." My reasons for requesting the presence of these two officers in particular, must be obvious to all those at all conversant with the recent military history of British India. In 1842, Sir George Pollock, being called upon to

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avenge our losses and disasters in Affghanistan, traversed and re-traversed, with a large army, the country of the Punjab, or land of the five great rivers, each varying from 300 to 500 yards in width. Throughout these difficult operations Sir Frederic Abbott was his chief engineer, and superintended the crossing of our troops, with all their munitions of war, over these great and formidable rivers, and the same able and scientific officer was subsequently called upon, in 1846, to construct the celebrated bridge of boats across the Sutlej River, for the invasion of the Punjab by Lords Hardinge and Gough, during which he partook in the glory of our arms in the great Seikh campaign. These two officers were, therefore, peculiarly well qualified to appreciate such an invention as that which I laid before them, and Sir Georg Pollock's first remark to me, after witnessing the experiments, was, "How invaluable such waggons as these would have been to me, in the Punjab!"*

It is unnescessary that I should, at present, enter into the details of these experiments, as I shall shortly have occasion to read the Official Report of Colonel Tulloh, Superintendent Royal Carriage Department at Woolwich, on some precisely similar trials subsequently made by him, by order of the War department. Suffice it to say, that, by the two distinguished officers just named, it was fully tested and approved, and pronounced by them to supply what had long been the desideratum in India, viz. a really efficient substitute

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* Sir G. Pollock was present at the first delivery of this Lecture, and on the 7th May ensuing addressed to Major Eyre the following valuable testimony:— "If I could have had the benefit of Mr Francis' carts when I crossed the five rivers of the Punjab, the soldiers would have been saved some day's hard labour.

I was detained a day or two at each river, whereas, with his carriages, I could have crossed each river in three or four hours without difficulty, and without fatiguing the troops".—(Signed) George Pollock.

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for the cumbrous and expensive pontoons in present use, besides being applicable to a variety of other useful purposes, to some of which I will presently advert. I would not have it supposed, however, that I mean hereby to *find fault* with, or undervalue the admirable pontoons in present use with the British army. The distinguished names of *Blanchard* and *Pasley* are sufficient guarantee for the practical value of their inventions in this line; and circumstances may frequently arise, both in peace and war, where their pontoons would, perhaps, have the preference over all others. Still, I would have all marching armies as *independent* as possible of all such extraneous assistance. The more means a general can muster wherewith to facilitate the movements and operations of his army, the more boldly can he look danger in the face by day, and the more comfortably can he repose from his fatigues and anxieties by night.

39. That great military authority, Sir Howard Douglas, has devoted a valuable volume to the subject of military bridges, and the passage of rivers in military operations. In reference to the difficulties that frequently beset our armies in the East, his observations seem to me so applicable to the matter now under discussion, that I am tempted to quote one or two passages. He says,

"Provision for the passage of rivers, in the earlier operations of ordinary marches, may be made without much difficulty; for they are nearer to resources that may be made available. But when, having crossed many rivers which may have become fordable, the passage of others which are unfordable is to be undertaken, near or in the presence of an enemy, the operation will entirely depend upon the state of the bridge equipment which the army may have brought with it, or upon the means which may be found on the rivers in the seat of the operation. *Upon the latter it is never safe to depend.* An army relying entirely upon these is *never safe*, and *ought not to be successful.* Whatever be its qualities and its force, the operations in which it is engaged will depend mainly upon material means; and there can be no more dis-

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creditable cause of failure, on the one hand, and no more obvious means of producing it, on the other, than for an army to trust to such contingencies."

Every one must admit the force of these observations, and it must be equally obvious, that an army, well supplied with floating metallic waggons, might boldly pursue its onward career, through such countries as Sir Howard Douglas describes, however frequently intersected by deep streams, without being checked or discouraged by any such disastrous results as are here so emphatically and so faithfully pointed out.

40. As the most hopeful channel, whereby to create an interest in this matter among the War Office authorities, I first addressed myself to the Earl of Ellenborough, whose experience in war enabled him at once to perceive, at a single glance (as the Emperor Napoleon has since done,) the importance of the invention. His Lordship lost no time in communicating the contents of my note to Lord Panmure, and the result was, that Colonel Tulloh, the able and energertic Superintendent of the Carriage Department at Woolwich, was directed to place himself in communication with Mr. Francis, with a view to making a trial of his waggon. To save him the delay attendant on procuring one from New York, I made mine over to him. On the 30th December, it was subjected to a variety of experiments at Woolwich, and I am happy to have it in my power to make known the successful result in Colonel Tulloh's own words.

" War Department, Pall Mall,
1*st January*, 1856.

Sir,

" Agreeably to your request, I have the commands of the Secretary of State for War, to transmit to you the inclosed 'Copy,' of a Report from the Superintendent, Royal Car-

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riage Department, dated 12th ultimo, upon your Patent Corrugated Metallic Waggon.

"I am,

"Sir,

"Your most obedient servant,

[Signed] "J Wood.

"Joseph Francis, Esq.

"Care of Major Vincent Eyre.

"Athenæum Club,

"Pall Mall."

[Copy]

"Royal Carriage Office,
"*12th December*, 1855.

"Sir,

"In compliance with the order from Lord Panmure, dated the 13th August, 1855, and your Minute of the 17th August, 1855, upon my letter of the 16th of the same month, ordering me to carry my recommendation for the purchase of Francis' Patent Corrugated Metallic Waggon into effect, and when obtained, to give my opinion, &c.,

"I have the honour to report, that I lost no time in writing to the parties in New York; and a few days since I received the waggon in question, with which, on Friday, the 13th ultimo, an experiment was made in the presence of Mr. Francis, the patentee.

"It was first placed it the water, with the whole of its running gear attached, including the pole; the weight was 17 cwt. 0 qrs. 4 lbs. Sixteen men then got in, and their

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weight amounted to 25 Cwt.; this brought the waggon down to about a foot from the top. Attempts were then made to upset it in the water by thewhole of these men bearing down, first on one side, and then on the other; but without effect. The upper edge of the waggon could not be brought below the water. The same experiment was tried with only six men in it, and with the same result. The next trial was with the body alone, the running gear being detached and allowed to sink in the water; attempts were again made to upset it without effect. It was then loaded with planks, and two men, weighing in all 34 cwt.; but neither in this case could any rolling bring the upper edge under water. Four of the bodies connected together form an excellent raft, capable of supporting any heavy ordnance of the service; and by keeping the running gear attached, they can be run in and out of the water with great facility. The weight of the waggon body alone is 5 cwt. 0 qrs. 7 lbs.; with its wheels, &c., complete, 17 cwt. 0 qrs. 4 lbs., being rather more than that of our old Flanders waggon. There are many circumstances in which a waggon body of this description could be found very useful; and by making some alterations in its construction, as stated by Mr. Francis, it could be made to pack up in sections, in a small compass, on shipboard. Any damage done to the corrugated iron can be easily repaired. The running gear possesses no advantages over our own; it is similar in construction to the American Lumber Waggon, but much heavier. The feeding trough can be fixed on the pole, for feeding. Two of them connected together form a small boat, capable of conveying one person across a stream in order to make a communication with the opposite side, which might be found useful. *I am, therefore, of opinion, that the invention might prove valuable to the service; and I beg to recommend it strongly to the attention of the Minister of War;* for, with the improvements which are capable of being made by reducing its weight and renderingit portable, I have no doubt this material, from the peculiar form of the

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corrugations affording such great strength, might be made highly useful for carts and waggons, as well as pontoons.

* * * * * *

"I have the honor to be,

"Sir,

"Your most obedient Servant,

[Signed] "Alex. T. Tulloh, Col. R. A.

"Supt. R. C. D."

41. There the matter has since rested. The Minister for War probably felt averse to the introduction into our military service of any extensive change in the field equipment of any army at that critical period; although it can scarcely be doubted that waggons of this description would have been considered by our Generals in the Crimea a valuable acquisition, to replace the wooden conveyances originally sent out, and which had soon become unserviceable, from the very severe nature of the service they encountered,

42. The emphatic approval of an officer so eminently qualified as Colonel Tulloh to form a sound practical judgment on a matter so entirely within his own province, could scarcely have failed, under ordinary circumstances, to settle the question at once. The time has passed since the self-reproach of Medea could be fairly applicable to our War Department—"Video meliora—*proboque*—deteriora sequor." It is to be hoped that a new and more spirit-stirring motto now distinguishes their banner and animates their counsels—"Excelsior."

43. Meanwhile, Mr. Francis has found some substantial consolation in that summons from the Emperor Napoleon to which I have already alluded, and which has resulted in the prompt establishment of a large manufactory in Paris, by the Emperor's express desire, and under his own immediate patronage, for the supply of metallic bodies of all shapes

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and sizes to meet the various requirements of the French service.

44. The practical results of the use of these waggons* in the United States army, for upwards of a year, has led to further orders to supply the wants of the service, and an entire substitution of metallic for wooden waggons is gradually taking place. To General Davis, the American Secretary at War, much credit is due for putting the invention to the test in the United States army, and thus deciding on its merits.

45. The account of the exhibition in the river Seine at Paris, before the Emperor, on the 2nd of February, as published in the *Moniteur*,† officially, has drawn the attention of the heads of two other powerful Governments of Europe to the subject, with whom the inventor is now in communication. I am also happy to have it in my power to state, that, owing to the favourable representations of sir G. Pollock and Sir F. Abbott, the East India Company have determined to give the waggons a trial in each of their presidencies in India. Sir F. Abbott has suggested a modification of the form of the metallic bodies, whereby each would form a demi-pontoon, and might be fitted on the common country bullock carts and employed to carry the commissariat supplies of marching armies on service. When required, they might be easily formed into floating rafts, or temporary bridges.

46. Each body would, in this case, be divided into two compartments, as shown in the model; and two bodies being united end to end, the two central compartments would be filled up with closely packed bags of dry fodder (whereof an abundant supply invariably accompanies an Indian army.) This would form a sufficiently substantial roadway, when covered over with such brushwood as the country might afford, and which is almost everywhere obtainable, and by these

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* See Appendix E.

† See Appendix F.

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simple expedients, would be saved the trouble and expense of conveying the heavy and cumbersome equipment usually considered indispensable for an ordinary pontoon bridge.

47. The small model, now in my hand,* is a flat-bottomed bateau, much used in the United States for lake and river service, both with land troops and with marines. Each bateau contains two water-tight compartments, one for powder, the other for stores; and, in such services as our Indian troops, have been recently exposed to in Burmah, during the late war. such bateaux might have been turned to excellent account. I am informed they elicited the marked approval of the Emperor of the French.

48. Having thus cursorily introduced to your notice this invention, which bids fair to become an important feature in modern warfare, I leave it to the consideration of abler men, in the full belief that, as its merits have been already recognised by the scientific officers at Woolwich, it cannot fail to be brought, sooner or later, into general use. It is merely a question of *time*. Meanwhile, the earnest and unhesitating way in which it has been already adopted by the French Emperor, affords sufficient guarantee for its intrinsic worth, to such as might otherwise harbour a doubt on the subject.

49. To those who guide and control the affairs of our Indian empire, I would suggest, as a matter well worthy of their early consideration, the very great saving that might be effected in our army and ordnance commissariat departments, by the *substitution of corrugated galavanised iron, or copper, for wood, wherever practicable.* It will be found to defy alike the destructive effects of fire, heat, wet, dry-rot, and insects. Year by year, *our timber forests are dwindling away*, and it becomes more and more difficult to obtain well-seasoned wood for the various requirements of Government. Here is a never-failing and enduring *substitute*. In India it would be most desirable to abolish altogether the use of

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* See Plate 51.

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wood in the bodies of our ammunition waggons and store carts, in the roofs and doors of our public sheds, as well as in our sea and river boats; and I feel satisfied, that the saving thus effected from year to year, throughout the three presidencies, would very soon be evidenced in a very remarkable manner in our annual financial statements.

APPENDIX E.

Office of the Quarter-Master General U. S. Army,
Washington, D. C. April 30, 1855.

Dear Sir,—Having informed me that you intend visiting Europe, for the purpose of introducing your Manufactures of Corrugated Galvanised Iron, it is my wish that you may have my opinion in regard to them, hoping that it may be of some service to you.

Of the Metallic Life-Boats and Barges, it is only necessary to remark that their reputation is so well established, and their usefulness so fully conceded by all in this country who have had an opportunity of testing them, that nothing I can state can add to it. I shall, therefore, confine my remarks to the waggon-body, which has been made under the direction of the secretary of war for army purposes.

It was very desirable in this country to have a waggon body that might be used in case of necessity as a boat or pontoon in crossing the numerous rivers and streams in our widely extended country west of the Mississippi River; while it would at the same time answer all the ordinary purposes of transportation, thereby saving expense to the public, by dispensing with pontoons, which could only be applied to the one purpose.

In this, I am happy to be able to state that you have been entirely successful, and that after repeated experiments and tests in the presence of the Secretary of War and members of the Senate and House of Representatives of the United States, the Quarter Master General and other

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officers of the army, it has been adopted into our service, and is now being used on our frontiers in the Indian country.

The weight of the metallic body is not greater than that of the wooden one, and it being capable of sustaining the running gear (wheels &c. &c) in addition to a moderate load in crossing streams, is a desideratum which will suggest itself to all, and especially to military men.

In case of necessity, the body can be detached from the carriage and used as a boat, and by connecting four or six of them, with a plank covering, a boat can be made of them by which the heaviest pieces of Artillery used in the field can be safely conveyed across a river. They can also be used in the construction of a military bridge.

From the test I have personally superintended and seen applied to it, I have full confidence in the improvement, and I cheerfully recommended it as being far superior to any thing of the kind which has been used in our service, and hope that you may be successful in introducing it into other countries, where it may be found necessary for either public or private uses.

With the best wishes for your health, and a speedy and safe seturn to our country and your home,

I remain, dear Sir,

Very respectfully your friend and obedient servant,

(Signed) Charles Thomas, Lieut. Colonel,
Deputy Quarter Master General U. S. Army.

Joseph Francis, Esq: New York.

APPENDIX F.

From the "Moniteur."

L'Empereur, accompagné du ministre de la guerre, d'un aide de camp et d'un officier d'ordonnance, s'est rendu, le 2 février, sur les bords, de la Seine, près de l'Ecole militaire,

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pour être témoin des expériences faites en vue de démontrer les qualités d'un chariot militaire, de métal cannelé, que M. Francis, de New-York, avait construit pour le présenter à Sa Majesté.

M. Francis commença par donner des renseignements sur son mode de construction et sur les procédés employés pour donner une grande force à un métal très-mince et trés-léger, et en fournit la preuve en frappant la caisse de toutes ses forces, à coups redoublés et au même point, avec un gros marteau à long manche. Il fit ensuite lancer le chariot, avec tout son train, dans l'eau, où il flotta comme un bateau; les hommes qui y étaient embarqués au nombre de seize, se portèrent en masse sur les côtès sans pouvoir, malgré tous leurs efforts, faire arriver les bords au niveau de l'eau. Le chariot fut après cela dirigé sur le courant de la revière, afin de montrer qu' une forte charge pourrait, par ce moyen, être transportée d'une rive à l'autre sans qu'il fût besoin d'ôter les roues: de sorte qu'un train de ces chariots pourrait continuer à suivre sa route saus retard.

Ensuite, le train ayant été détaché, on fit manœuvrer la caisse séparément, comme un bateau à rames.

Ces expériences obtinrent l'approbation de Sa Majesté, qui eut la bonté d'appeler deux fois M. Francis, et de le féliciter sur son succés.

L'Empereur se fit donner par M. Francis des renseignements détaillés sur ses bateaux métalliques, qui ont acquis une grande célebrité, et dont des modèles étaient sur les lieux. Après un examen circonstancié qui dura plus d'une heure, Sa Majesté témoigna l,intérêt qu'elle prenait à ces inventions, comme étant une amélioration importante pour le service de l'armée et de la marine.

En même temps, M. Francis informa Sa Majesté de nouvelles officielles reçues de l'armée des Etats-Unis, rendant compte d'une expédition de 1,500 milles sur de très mau-

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vaises routes, expédition pendant laquelle ses chariots avaient traversé des revières, flottant avec leurs charges d' une rive à l' autre, sans qu' aucun cours d'eau eût pu en arrêter la marche.

Description of the Battle of Magenta (4th June 1859) and preliminary movements, from the published sources up to this date, 13th June 1859 with Plate.

Preliminary Movements

A. Positions of the French and Sardinians on the 28th May 1859.

The Sardinian army passed the Sesia on the 30th at Vercelli and moved on Confienza Vinzaglio, Casalino and Palestro, which they occupied after an action with the Austrians. On the 31st the Austrians attempted to drive them out of Palestro, but were repulsed. The French army had in the meanwhile been rapidly moving to its left, to turn the Austrian Right flank by Turbigo and Boffalora. Marshal Canrobert passed the Sesia at Prarolo on the 31st May, General MacMahon advanced from Vercelli on the same day.

B. Positions of the armies on the 2nd June.

On the night of the 2nd the Austrian armies retired from Mortara across the Po (as shewn by the dotted lines.) The Corps at Boffalora attempted to blow up the bridge there, but did not succeed in rendering it impassable.—The French protected by the Voltigeurs of the Guard threw a bridge over the Ticino at Turbigo.

On the 3rd General MacMahon's Corps, with the Voltigeurs of the Imperial Guard, crossed the Ticino at Turbigo; they encountered the Austrians (Cordon's Division of the 1st Corps) at Robecchetto, and repulsed them. The Sardinian army advaneed to Galleate and Marshal Canrobert's Corps to Trecate. The rest of the French army were at or near Novara.

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The Battle of Magenta, June 4th 1859.

Positions before the battle.

1. 2nd French Corps under General MacMahon advancing from Turbigo in two columns on Boffalora and Magenta, consisting of two Divisions (Generals Espinasse and La Motterouge) supported by the Voltigeurs of the Imperial Guard under General Camou.

2. Sardinian army passing the Ticino at Turbigo in order to support MacMahon's movements. They experienced so much delay in this operation that only one Division was able to follow him and that at a distance.

3. General Mellinet's Division, the Grenadiers and Zouaves of the Imperial Guard (Brigades Wimpffen and Cler) under General Regnault de St. Jean d' Angely, posted at San Martino, ready to force the passage of the river as soon as MacMahon's movement on Boffalora and Magenta should be sufficiently advanced.

4. The Corps d'Armées of Generals Neil and Canrobert advancing from Novara and Trecate.

5. 2nd Austrian Corps d'Armée (Prince Liechtenstein) and 7000 of the 1st Corps d'Armée (Count Clamm Gallas) in position at Magenta and Boffalora.

6. General Reischach's Division of the 7th corps d'Armée at Corbetto.

7. General Lilia's Division of the 7th Corps d'Armée at Casteletto.

8. 3rd Corps d Armée at Abbiate Grasso. The 5th and 8th Austrian Corps were near Binasco. The 9th Corps was on the Po below Pavia,

Description of the Battle.

9. About 2 P. M. General MacMahon's approach having been indicated by heavy firing, the Zouaves and Grenadiers of the Guard advanced over the Bridge of Boffalora, carried

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the heights near the Grand Canal and Village of Boffalora, and occupied Ponte di Magenta. They remained unsupported for some hours. MacMahon's advance had been checked,—the enemy having endeavoured to throw themselves between his two divisions, he had been obliged to make his right Division fall back towards the left one. Canrobert's advance, on the other hand, from Trecate, had been impeded by the encumbered state of the roads. The Sardinians, as before mentioned, had been delayed in the passage of the river at Turbigo.

10. General Reischach's Division advanced to retake Ponte di Magenta; they succeeded in this, but were driven out again.

11. The 3rd Austrian Corps advanced from Abbiate Grasso against the right flank of the French, in Four Brigades, General Ramming's Brigade on the right of the Canal, General Hartung's on the left, General Wetzlar's on the low ground near the river Ticino, and General Dürfeld's Brigade in Reserve.

12. About 6 P. M. General Picard's Brigade of the 3rd Corps, headed by Marshal Canrobert, arrived, followed by General Vinoy's Division of the 4th Corps, and General Renault's and Trochu's Divisions of the 3rd Corps.

13. About the same time General MacMahon's guns began again to be heard. He had completed his movement of concentration to his left, and proceeded to attack Magenta.

14. The Austrians opposed him, and endeavoured to pierce his centre between his two Divisions. MacMahon brought up the Guards to close his centre and at the same time threw forward his right and left wings to surround the Austrians. After a desperate fight, which lasted until 8 P. M. the latter retired through the village of Magenta. At the same time, after Ponte di Magenta had been taken and

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retaken several times, the Austrians were there also obliged to retire.

15. The 5th Austrian Corps had arrived on the battle field, and the Brigade of the Prince of Hesse took part in the defence of Magenta.

Corbetto was occupied by General Lilia, aud Robecco by General Gyulai himself during the night, and in the morning of the 5th, the Brigade of the Prince of Hesse made another attack on Magenta to cover the retreat of the Austrians.

AUSTRIAN TROOPS engaged at MAGENTA (From Count Gyulai's Report.)

1st Corps, Count Clamm Gallas, only 7000 men engaged.

2nd „ Prince Liechtenstein

3rd „ Prince Schwarzenberg (the Brigades commanded by Ramming, Hartung, Dürfeld and Wetzlar,) only about half the Corps engaged.

7th „ Zobel (Divisions commanded by Reischach and Lilia.)

5th „ Count Stadion (Brigade Prince of Hesse only engaged.)

FRENCH TROOPS engaged at MAGENTA (From the French official Report.)

Imperial Guard, Regnaud de St. Jean d' Angely

1st Division (Grenadiers and Zouaves,) commanded by Mellinet.

2nd Division, (Voltigeurs) commanded by Camou (attached to MacMahon's Corps.

2nd Corps—MacMahon

3rd „ Canrobert (Divisions commanded by Renault and Trochu.)

4th „ Niel (Division commanded by Vinoy.)

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Rules to find the weight of an iron ball from its diameter, communicated by Captain G. Carleton, Adjutant Horse Brigade Madras Artillery.

At page 8 of the Small Gunner's Assistant the following rule is given to find the weight of an iron ball from its diameter viz. as 64 or the cube of 4 is to 9 lbs. so is the diameter, cubed to the weight of the given ball.

N. B. A cast iron ball 4 inches in diameter will weigh nearly 9 lbs., and weights of balls of the same specific gravity are as the cubes of their diameters, hence the above rule, which will I believe always give a weight much in excess of the truth.

I venture to suggest the following rule, viz., cube the diameter and multiply by ·5236 which will give the solidity in cubic inches, which multiply by the weight of one cubic inch or ·263 lbs. for the weight of iron ball required.

The following results have been obtained from actual experiment in guaging and weighing 6-Pounder Shot.

In guaging a number of these shot the highest guage found was 3·54 inch the lowest 3·50, the intermediate guages of 3·53, 3·52 and 3·51 were also obtained:—their actual weights by scale are set opposite these guages as follows.

	lbs.	oz.	drams.
3·54 inch...........................	5	15	6½
3·53 „	5	15	3
3·52 „	5	15	0
3·51 „	5	13	13
3·50 „	5	13	4

Now by the latter rule the weights calculated are as follows—

$$\left((3{\cdot}54)^3 \times {\cdot}5236\right) \times {\cdot}263$$

$$\text{or } \left(44{\cdot}3618 \times {\cdot}5236\right) \times {\cdot}263$$

$$\text{or } 23{\cdot}22787 \times {\cdot}263 = 6{\cdot}1089 \text{ lbs.}$$

lbs.	oz.	drs.		oz.	drs.	
= 6	1	11	or	2 and	4¾	more than found in weighing.

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By Gunner's Assistant Rule $64 : 9 :: (3{\cdot}54)^3$ lbs.

or $64 : 9 :: 44{\cdot}3618$

that is $\dfrac{44{\cdot}3618 \times 9}{64} = 6{\cdot}2383$ lbs.

	lbs.	oz.	drs.
or	6	3	13

oz. drs.

or 4 and $6\frac{3}{4}$ more than found in weighing.

2nd. $((3{\cdot}53)^3 \times {\cdot}5236) \times {\cdot}263 = 6{\cdot}0573$ lbs.

lbs. oz. drs. oz. drs.

= 6 0 14 or 1 and 11 more than found in weighing.

By Gunner's Assistant Rule

$64 : 9 :: (3{\cdot}53)^3$ lbs.

$64 : 9 :: 43{\cdot}9869$

$\dfrac{43{\cdot}9869 \times 9}{64} = 6{\cdot}185$ lbs. or 6 lbs. 2 oz. 12 drs.

oz. drs.

or 3 9 more than found in weighing.

3rd. $((3{\cdot}52)^3 \times {\cdot}5236) \times {\cdot}263 = 6{\cdot}0059$ lbs.

or 6 lbs.

which is 1 oz. more than found by weighing.

By Gunner's Assistant $64 : 9 :: (3{\cdot}52)^3$ lbs.

$:: 43{\cdot}6142$

$\dfrac{43{\cdot}6142 \times 9}{64} = 6{\cdot}1322$ lbs.

	lbs.	oz.	drs.
or	6	2	2

oz. drs.

which is 3 and 2 more than found by weighing.

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4th. $\left((3{\cdot}51)^3 \times {\cdot}5236\right) \times {\cdot}263 = 5{\cdot}9549$ lbs.

	lbs.	oz.	drs.
or	5	15	4

which is 1 oz. 7 drs. more than found by weighing.

By Gunner's Assistant Rule $64 : 9 :: (3{\cdot}51)^3$
$:: 43{\cdot}2435$

and $\dfrac{43{\cdot}2435 \times 9}{64} = 6{\cdot}0811$ lbs.

	lbs.	oz.	drs.
or	6	1	4

which is 3 oz. and 7 drs. more than found by weighing.

5th. $\left((3{\cdot}50)^3 \times {\cdot}5236\right) \times {\cdot}263 = 5{\cdot}9041$ lbs.

	lbs.	oz.	drs.
or	5	14	7

which is 1 oz. 3 drs. more than found by weighing.

By Gunner's Assistant Rule $64 : 9 :: (3{\cdot}50)^3$ lbs.
$:: 42{\cdot}875$

$\dfrac{42{\cdot}875 \times 9}{64} = 6{\cdot}029$ lbs.

= 6 lbs. 0 oz. 7 drs. which is 3 oz. and 3 drs. more than found in weighing.

So we find that the latter rule is from 2 oz. to 2 oz. 2 drams further from the truth than the former.

I beg in conclusion to remark that the weight of 6-Pounder Shot as shewn at page 7 of the Gunner's Assistant, viz. 5 lbs. 10 oz. would appear to be altogether too little, immediately below it moreover the diameter of the shot is shewn at what it ought to be as a maximum, viz. 3. 568, the weight of which would be probably fully 6lbs if tested by scales, according to proposed rule it would be 6 lbs. 3 oz. 15 drams and by the rule in Gunner's Assistant 6 lbs 6oz. 3 drs., in

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Straith at page 94 of his Memoire on Artillery, the weight of 6-Pounder Shot is laid down 5 lbs. 15 oz.

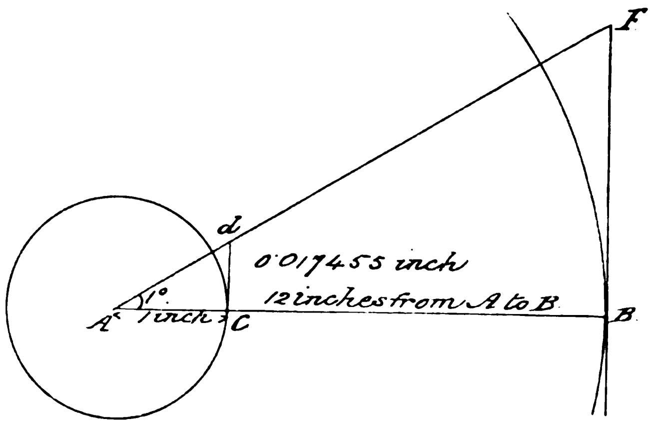
(Signed) G. CARLETON, Captain,

Adjutant H. A.

15*th December* 1859.

To find the length of tangent of any degree or part of a degree to any radius with reference to the tangenting of guns, communicated by Captain G. Carleton Adjutant Horse Brigade Madras Artillery.

1st. To find length of tangent of 1° to radius of 12 inches by Diagram illustrated.



To radius 1 inch the length of Natural tangent of 1° is 0·017455, equal above to *Cd*; then to find *BF* the natural tangent of 1° to a radius of 12 inches, we have the two triangles *ACd* and *ABF* similar, so it will be

as	*AC*	:	*AB*	::	*Cd*	:	*BF*	
or	1	:	12	::	0·017455	:	20946	the natural tangent of 1°
					12			to radius 12 inches.
					·209460			

In like manner can be found the length of tangent to any proposed radius.

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2nd. To find the natural tangent of $\frac{1}{4}°$ to $\frac{1}{2}$ an inch radius, the tangent of $\frac{1}{4}°$ or 15′ is 0·0043634 to radius of one inch.

$$\begin{array}{l} \quad\text{inch.}\ \ \text{inch.} \\ \text{then as } 1 : \tfrac{1}{2} :: 0{\cdot}0043634 : \\ \qquad\qquad\qquad\qquad\quad \tfrac{1}{2} \\ \hline \end{array}$$

0·0021817 the length of natural tangent of $\frac{1}{4}°$ to $\frac{1}{2}$ an inch radius, and in like manner to get the length of tangent to any given angle at any given radius. Take out the natural tangent from the tables and multiply it by the proposed radius, but to find the same from a table of logs. add the log. of the proposed radius to the log. tangent of the given angle, their sum will be the log. of the length of the tangent, take out the natural number corresponding from the table of logs. of numbers and we have the natural tangent to the proposed radius and angle.

Example	log. tan. 0° 15′	7·63982
	log. of $\frac{1}{2}$ or 0·5	—1·69897
	Nat. No. 0·0021817	7·33879

N. B. As all the sines and tangents in the log. tables are increased by 10 in the index, take 10 from index 7 and there remains—3·33879; now in finding out the natural number for—3·33879 the—3 shows that the decimal point will be three places from unity, first then take out the natural number for ·33879 which is 21817, then as negative index —3 shows it must commence in the 3rd place from unity, it must be written thus ·0021817 and so for any similar case, here it is seen the first figure 2 is made the 3rd after the decimal point.

The same subject is considered in the June 1857 number of the Records page 469.

The lengths of tangent scale for the various degrees in the four 6Pdr. Guns and two 12 Pdr. Howitzers in use with the

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C. Troop, as found by careful measurement are shewn as follows, as also what they should be according to calculation.

Length of tangent scale calculated for each degree up to 6° for a 6-Pounder Gun, allowing length of Gun to be 60 inches.

			Inches.
Nat. Tangt. of 1°	·0174551 × 60 inches	=	1·0473060
Nat. Tangt. of 2°	·0349208 × 60 „	=	2·0952480
Nat. Tangt. of 3°	·0524078 × 60 „	=	3·1444680
Nat. Tangt. of 4°	·0699268 × 60 „	=	4·1956080
Nat. Tangt. of 5°	·0874887 × 60 „	=	5·2493220
Nat. Tangt. of 6°	·1051042 × 60 „	=	6·3062520

It is found however that the front of dispart on the guns examined is at least ·5 inch in rear of the face of gun muzzles, so that the length of gun to be measured is not above 59·5 inches, upon which calculation the lengths of scale for the different degrees will be as follow.

Nat. Tangt. of 1°	·0174551 × 59·5 inches	=	1·0385784
Nat. Tangt. of 2°	·0349208 × 59·5 „	=	2·0777876
Nat. Tangt. of 3°	·0524078 × 59·5 „	=	3·118[illegible]641
Nat. Tangt. of 4°	·0699268 × 59·5 „	=	4·1606146
Nat. Tangt. of 5°	·0874887 × 59·5 „	=	5·2055776
Nat. Tangt. of 6°	·1051042 × 59·5 „	=	6·2536999

Having carefully measured the lengths on each tangent scale for every degree up to 6°, the mean length of scale for the 1st degree is found to be 1·30 inches, and as the lengths marked for the other degrees from 2 to 6 inclusive are about exactly equal, the differences being unprogressive, irregular, and apparently accidental, the average of these also is taken viz 1·07, and it is found that allowing the full length of 60 inches to the gun the length of scale given

for the 1st degree is.................................. ·25 too long
or allowing only 59·5 inches for gun............. ·26 too long

in the same way the lengths of scale

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for the other degrees are found to be either ·27 or ·29 too long for the 2nd degree—

for the 3rd degree either...................... ·29 or ·32
for the 4th „ „ .... ·31 or ·34
for the 5th „ „ .... ·33 or ·37
for the 6th „ „ .... ·34 or ·39

of an inch longer than should be, and it will be observed that the disproportion increases as the range becomes greater, though the incorrectness throughout is mainly caused by the great excess in scale for 1°.

Again, calculating the same for each degree up to 8° for a 12-Pounder Howitzer allowing length of Howitzer to be 45·25 inches.

Nat. Tangt. of 1°	·0174551	× 45·25	inches	=	·78984327
Nat. Tangt. of 2°	·0349208	× 45·25	„	=	1·58016620
Nat. Tangt. of 3°	·0524078	× 45·25	„	=	2·37145295
Nat. Tangt. of 4°	·0699268	× 45·25	„	=	3·16418760
Nat. Tangt. of 5°	·0874887	× 45·25	„	=	3·95886367
Nat. Tangt. of 6°	·1051042	× 45·25	„	=	4·75596505
Nat. Tangt. of 7°	·1227846	× 45·25	„	=	5·55600315
Nat. Tangt. of 8°	·1405408	× 45·25	„	=	6·35947110

but the length of Howitzer to be measured is actually about ·5 inch short of the above, the dispart being that distance in rear of face of the muzzle in each Howitzer, then allowing only 44·75 inch for length of Howitzer we find the Tangent for each degree should be as follows—

Nat. Tangt. of 1°	·0174551	× 44·75	inches	=	·781115725
Nat. Tangt. of 2°	·0349208	× 44·75	„	=	1·5626958
Nat. Tangt. of 3°	·0524078	× 44·75	„	=	2·3452490
Nat. Tangt. of 4°	·0699268	× 44·75	„	=	3·1292243
Nat. Tangt. of 5°	·0874887	× 44·75	„	=	3·9151193
Nat. Tangt. of 6°	·1051042	× 44·75	„	=	4·7034129
Nat. Tangt. of 7°	·1227846	× 44·75	„	=	5·4946108
Nat. Tangt. of 8°	·1405408	× 44·75	„	=	6·2892008

Having carefully measured as before the length on each tangent scale (to $\frac{1}{100}$ths. of an inch) for every degree up to 8°, the mean length of scale for the 1st degree is found to be ·92 inch, and the lengths marked for the rest from 2° to 8° inclusive are all equal, viz. ·78 inch, so taking the mean lengths measured and allowing the length of Howitzer to be, in one case 45·25 inches and in the other 44·75 inches, deducting the ·5 for the distance the dispart is in rear of face of the muzzle, the excess in lengths of scale for the various degrees in either case is found to be as follows viz.

	·92	·92 measured.
	·789	·781 calculated.
for the 1st degree either	·131 or	·139 too long.
	1·70	1·70 measured.
	1·58	1·56 calculated.
for the 2nd degree either	·12 or	·14 too long.
	2·48	2·48 measured.
	2·37	2·34 calculated.
for the 3rd degree either	·11 or	·14 too long.
	3·26	3·26 measured.
	3·16	3·12 calculated.
for the 4th degree either	·10 or	·14 too long.
	4·04	4·04 measured.
	3·95	3·91 calculated.
for the 5th degree either	·09 or	·13 too long.
	4·82	4·82 measured.
	4·75	4·70 calculated.
for the 6th degree either	·07 or	·12 too long.
	5·60	5·60 measured.
	5·55	5·49 calculated.
for the 7th degree either	·05 or	·11 too long.
	6·38	6·38 measured.
	6·35	6·28 calculated.
for the 8th degree either	.03 or	·10 too long.

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It will be observed that the disproportion in length of scale to the various degrees increases with the elevation in the 6-Pdr., and decreases with the elevation in the 12 Pdr. Howr., if this be correct in practice, the Howitzer Elevation should be more correct as it increases up to 8°, and the 6-Pounder Gun elevation should be less correct as it increases up to 6°; might it not be worth while to test this at the ensuing annual practice, allowing the guns to be somewhat heated prior to commencing the experiment, and cautioning the gunners against the too common fault of not lowering the eye along the line of metal, but looking over the nick in the base ring or tangent scale instead of through it, by which the elevation is increased, but to arrive at any satisfactory conclusion the extent of windage should be taken into consideration, which it is premised is far greater than that for which the tables are calculated, viz. ·101; the mean calibre of the 6 Pounder attached to the C. Troop is 3·695 instead of 3·668, and the mean diameter of shot 3·514, making windage on an average to be ·181 of an inch or $\frac{1}{20}$ of the calibre, the latest authorities calculate that from $\frac{1}{3}$ to $\frac{1}{2}$ of the effect of the powder is lost by a windage of $\frac{1}{16}$ the calibre, and the loss of velocity by windage is proportionate to the windage, besides the loss of velocity by windage through the escape of the elastic fluid, there is to be taken into account the loss from the diminished weight of the shot, supposing the calibres of the guns to be equal and to remain constant, vide Boxer's treatise on Artillery Section I, part 1, page 56, and at page 60 of the same is explained how the same amount of windage will affect the range in guns of different calibres in a greater degree in proportion as the calibre of the gun is smaller; in conclusion I would beg to draw attention to the method of reducing windage noticed and commended at page 262 of Lefroy's hand book for Field Service.

(Signed) G. CARLETON, Captain,
Adjutant Horse Artillery.

Bangalore, December 16th, 1858.

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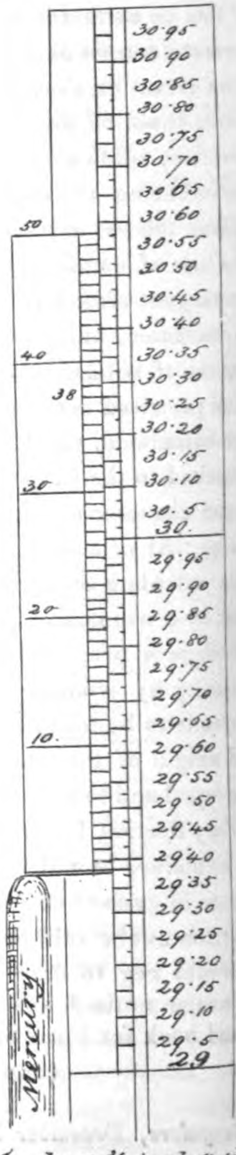
To read off the Barometer to 3 places of decimals, communicated by Captain G. Carleton, Adjutant Horse Brigade Madras Artillery.

Rule.—Bring down Zero of the Vernier on a level with the top of the Mercurial column as shewn in the diagram, then look up the vernier until a division is found on it which exactly coincides with a division on the Barometric scale to the right, it is here seen that 38′ on the vernier so coincides, and the Zero of the vernier being below the 30th inch of the Barometric scale and between the 29·35 and 29·40 divisions, therefore the height of the mercurial column is 29·35 + ·038 inches, equal 29·388 inches, the correct height to 3 places of decimals.

29·35
·038
———
29·388
———

I should have said that first of all I put down the height of the mercury as near as the Barometrical scale itself shews, which is here 29·35 and to this there is added that observed on the vernier afterwards.

(Signed) G. Carleton, Capt.
Adjutant Horse Artillery.



Scale. 2¾ inch to inch

The Armstrong Gun.

There has been no warlike invention of modern days which has excited higher hopes, and certainly none about which such a mystery of secrecy has been maintained, as in all relating to the performances and manufacture of the Armstrong gun. Like the well-known wild-goose shot, no tale is too marvellous for credence as to the accuracy and range of this celebrated ordnance, while, on the other hand, the Eleusinian mysteries or the secrets of Freemasonry are supposed to be as nothing when compared with the obscurity which shrouds all pertaining to the construction of the pieces themselves. Now, on both these points, and without at all departing from the rule of regarding the interests of the public in this matter, we think we may venture to afford our readers a little information. We may premise, first of all, that there is scarcely any tale current regarding the enormous range and deadly accuracy of the Armstrong gun which is not more or less true. In fact, the power which this artillery possesses is almost beyond belief, and, if our artillerymen are but educated up to the proper use of these most scientific weapons, there is no achievement in the history of modern warfare which is not easily to be surpassed. The secrecy which envelopes all the long and elaborate processes by which every part of the the gun is brought to the highest degree of manufacturing excellence has, however, become useless, because totally unnecessary. We by no means intend to deny that the gun undergoes some peculiar process, or processes, the reason for which is known only to one or two of the chiefs of the two great factories at Elswick and Woolwich, and which is so carefully concealed that it is made a rule never to mention it even among themselves. This we may term the common secret, for if anything is more certainly known than another it is that this mere verbal concealment must in the natural course of all such things before long be broken. Fortunate is it, therefore, that there exists beyond this little mystery another and the best of all

known safeguards under which any manufacturing process can ever be concealed—the secret which can neither be told nor stolen—the secret of unmatched mechanical and manufacturing skill. The English are the foremost people in the world for their skill and art in iron work, and, taken as a whole, the Armstrong gun is, for lightness, strength, and the minute mathematical accuracy of all its many component parts, the very finest specimen of wrought iron work that has ever been put together in this country. Here is a secret beyond the reach of either spies or traitors—a secret only within the attainment of nations which shall labour for it as we have done any time this century. No one ever thought of concealing the secret of the manufacture of locomotives; on the contrary, we at once set about trying to teach the world how it could best be done. What is the result? After 25 years' incessant schooling and sending our mechanics among the nations of the earth all people still come to us for their machinery and engines, all save the Americans, and even they rely on our aid for their greatest engineering triumphs. So confident are the managers of the Armstrong factories of these facts that in their opinion the public might safely be admitted to view the processes of manufacture, without the least fear that any amount of observation would ever penetrate the so-called mystery. What these numerous processes consist of we shall now briefly describe to our readers as clearly as we are able to convey in words the outline of a long and often obscure manufacture. The Government are often, and not unjustly, blamed for adherence to routine, to the neglect of rare and valuable opportunities. On the other hand, then, it is only just that when, as in the present instance, the War-office has exerted an extraordinary amount of firmness and activity in pushing forward the manufacture of these magnificent pieces of ordnance, it should get the credit for an amount of progress almost incredible with such a weapon and in such a space of time. Not the least obstruction is ever placed in the way of an occasional

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visitor to the Armstrong factories seeing the finished gun. In fact, a man would no more derive information from an inspection of the long, slim, inellegant-looking piece than one who had never seem steam machinery could make a pair of paddle engines from a mere glance into the engine-room of the Great Eastern.

It is in the forge shops that the long stages of manufacture commence—where men labour at works to which those of the Cyclops were mere jokes, and in which at first the visitor stands aghast to find himself involved in such a raging little world of furnaces and steam hammers,—where the glare is blinding, and the noise, smoke, dust, and clatter tremendous and unceasing. In one corner is a little hammer, possessed apparently by ten devils in steam, and which incessantly beats with a terrific reverberation upon a small round disc of copper; in another is the tube of a gun, through which a complicated arrangement of water-pipes passes, to keep it cool while the red-hot trunnion pieces are fitted and shrunk on. In one part stands a row of short iron tubes, about approaching which the visitor must be careful in the extreme, for dim as they look they are nearly all red-hot, and the air in their vicinity scorches like a blast from an oven. In other places men work with a battering-ram of iron, striking violently against the end of something sticking out of a furnace, the blows on which make the glowing brick-work leap and tremble, and threaten to let loose the mass of flame that roars within like thunder. On every side, in clouds of steam and choking dust, through the thick gloom of smoke, or labouring faintly in the white glare from ardent furnaces, men are seen busy, while every now and then these furnace doors fly open, and the crane drags forth a seething mass of metal, hissing and sparkling like a fire king, lighting up the factory with its brilliant whiteness, and leaving a train of glowing particles behind. Careful must the visitor be to give these dreadful masses a wide berth, as the workmen, protected by leather and their faces shielded

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by crape masks, drag them past to where the steam hammer thumps the reluctant pile of metal into a rough semblance of its future form, when, after roaring and sputtering under a stream of cold water, it is wheeled off to undergo another of the many stages by which it advances slowly towards completion. These and a score of other similar operations, too numerous to more than glance at, are the chief things which strike the visitor on first entering an Armstrong factory, and it is only after a time that he dimly perceives the object of each work and sees what it means and leads to. Let us commence at the beginning, and suppose that the manufacture of 25-pounder guns is going forward. In one corner of the factory is a very long but narrow furnace, in which are placed, as fast as they are wanted, bars of the finest wrought iron, some two inches square and 40 feet or so in length. In the manufacture of the 100-pounder Armstrong gun bars of not less than 90 feet would be required. In front of this furnace is a roller, the diameter of which is equal to the rough-made tube of a 25-pounder when first rolled. Directly one bar is heated to a low white heat it is wound out through an aperture in the door of the furnace slowly and closely over the roller. When the whole bar is thus coiled up as close as possible the roller is turned on end, and the coil (termed a No. 1 coil) at once knocked off. In this state, and having much the apppearance of a flattened corkscrew about three feet long, it is rolled away to a large furnace, where in 10 minutes it is heated to a bright white heat, placed on one end in an iron cylindrical case under a steam hammer, and flattened down and welded with tremendous blows till only about 2 feet 6 inches long. Three of these tubes make a complete 25-pounder gun.

As fast as the short lengths of tube are finished they are wheeled away into the turning shop—an immense place, where, though everyone is busy, the light and quiet are a relief after the sombre glare and dreadful uproar of the foundry beyond. Here the short lengths of No. 1 coil are

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bored inside and turned on the outside to within 1-10th of an inch of their pröper diameters, in order that the minutest flaw, if any should exist, in the welding may be discovered. When all is seen to be perfect they are again returned to the foundry, and two lengths of tube placed, with their ends touching, in a jet of flame from a blast furnace, where, when sufficiently heated, they are welded together by blows from the iron battering-ram we have already mentioned as worked by men against the furnace in so strange and rude a manner. Three No. 1 coils thus joined make the tube of the gun; but an immense amount of labour has still to be accomplished before it takes the field as the most perfect piece of ordnance the world has yet seen. Over the junction of the first and second tubes, near where the trunnions come, a second coil or tube, which has been rolled, welded, turned, and finished in a precisely similar manner to the first, is placed on the tube while in a bright red heat, and so shrunk on. Over this again comes the third coil, a shorter, massive belt of forged iron, to which the trunnions are fixed, and while this is shrinking on, the water-pipes we have alluded to pass a jet through the tube itself to prevent its heating. In this manner the tube of the gun is finished, but the breech has yet to be attached. In the first, second, and third coils we have here mentioned the fibre of the rolled iron is laid transversely round the gun, but with the breech piece, which has to bear the whole backward concussion of the explosion, such an arrangement of the fibre would yield to the first shot. The breech, therefore, is formed of several pieces of wrought iron, shaped like coarse wedges or the staves of a barrel, with the fibre of the iron running longitudinally to the gun, and all of which are welded and wedged together in one tubular mass under the steam hammer. This, like the No. 1, 2, and 3 coils, similarly turned down, rough finished, and shrunk on to form the breech while red-hot. Outside this again are two double coils of wrought iron, rolled on with their fibre at right angles with that of the breech piece underneath. In this way,

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then, having at the breech and trunnions a triple coat of rolled metal, the tube is finished, and looks like a long and very thin cannon from which the muzzle and breech has been cut off. While in this state its outside is turned down to its precise size, and the whole gun given over to the measurers, who, with an exquisitely fine instrument, termed a micrometer, measure each part with mathematical accuracy. Any portion that deviates more than the 3,000th of an inch from its exact size is condemned, cut out, and replaced. In this state it for the first time leaves the forging room, and passes to the finishing shop, where turning lathes, boring and rifling machines, with many others of eccentric forms and unknown uses, abound in all directions. Here the gun is first placed on end in the boring machine—a very beautiful and powerful piece of mechanism, which bores down vertically into four guns at once. Each gun is bored twice, and each boring occupies no less than six hours. The first time the gun is bored out to within 1-1000th of an inch of its proper diameter; at the second turning it is finished. When the boring is ascertained to be perfect to within half a hair's breadth the rifling is begun forthwith. This is, of course, a very simple part of the operation, the gun or tube being merely laid horizontally in a turning lathe, and the rifle grooves cut in it, one after another, in the course of about five hours. In the Armstrong gun there are 40 close fine grooves, each of a peculiar angular shape, about 1-8th of an inch deep, the pitch or turn of the rifling being slight—no more than one complete turn in 10 feet 6 inches. The next process is to cut a square hole, or 'slot,' as it is called, in the upper side of the breech, corresponding to where the touchhole of an ordinary gun would be, and to turn a deep fine-threaded screw in the open breech at the end of the gun, or as we may still continue to term it, the tube. At this stage of the manufacture, if nothing had ever been explained to the visitor, he would see at a glance the whole principle of the gun, and when shown what is termed the 'vent piece,' would even be able to fit,

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load, and fire the piece with ease. The powerful hollow screw which runs into the breech at the back is worked backwards with most perfect ease and rapidity by a common weighted handle. Thus, when about to be fired the powder and conical shot are introduced into the breech of the gun through the hollow screw, and deposited in the chamber. Behind these the 'vent piece' of steel faced with copper is dropped in from the opening above, and thus forms the breech of the gun, which a single turn of the screw wedges up and keeps immovably in its place behind the charge. When fired the screw is turned back, the vent piece removed, the chamber of the gun sponged out through the hollow screw, the powder and conical shot are again placed with the vent piece behind them, the screw closed up, and the gun fired in a single minute. As a matter of course, the touchhole is through the vent piece down into the chamber of the gun, with which it communicates by means of a common friction tube. The fitting of the vent piece, in order to prevent all escape of the explosive force, is a matter on which almost the entire efficiency of the gun depends, and therefore it is regulated to a degree of nicety which seems almost useless, till the reason for such rigid exactness is known. All of them, therefore, are made alike, each vent piece for each class of gun being precisely similar in form, size, and weight. Thus a vent piece made for one 25 or 40 pounder will fit indiscriminately all other guns of the same calibre in the service. The exactness of the copper ring which faces these vent pieces, and fits into the end of the rifled barrel, is also a matter of chief moment. It is the manufacture of this ring which occupies the little steam hammer with the incessant uproar we have mentioned, so that it is always the first object to attract attention on entering the forge room. The gun thus fitted with its breech piece and screw is complete as a piece of ordnance, and has only to be sighted for its long range, and stained to that rich deep tint which makes it look so well, and shows so beautifully the fibre ofthe iron wind-

ing round and round the gun up to the slender muzzle. This staining operation is soon effected by painting over the metal with a mixture of lime water and acid, and leaving it in a moderate oven to oxidize. The slight brown rust is then wiped off and the gun polished to the tint of a new finely-twisted barrel. The screw handle and vent piece are tinted of the richest purple steel colour.

The operation of 'sighting' for the long range is a far more delicate and important matter, for we need scarcely say how much of accurate firing depends on this. The common sight for ordinary short range is placed in a line from the back of the breech to above the muzzle. The long range is affixed on the right hand side of the muzzle—to counteract in some measure by this line of sighting the tendency which the gun has to throw its ball to the left of the mark. This deviation to the left, however, is common to rifled cannon of every kind which have the pitch of their screw turning in that direction, and *vice versa*. The sight is a perforated one, and of of such extreme delicacy as to enable the most minute object to be covered at almost any distance. In fact, nothing which can be clearly seen is too small to be aimed at, and to be aimed at by the Armstrong gun is to be hit.

Thus, then, so far have we given our readers an outline of the main features connected with the manufacture of this as yet unequalled gun. At the commencement of the present financial year (not quite 10 months ago,) the Government, or rather, as we may more properly term it, the war-Office undertook that 100 of these pieces of ordnance should be completed before 1860. Already, owing to the untiring energy of Sir Benjamin Hawes and others, this number has been nearly trebled. What may not be hoped this year from the combined efforts of the War-office, from the increased experience, resources, and indefatigable activity displayed by Sir William Armstrong, by the managers of his Elswick works and by Mr Anderson, the manager of the most impor-

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tant factory of all at Woolwich? But already have we far exceeded the limits we assigned to ourselves at the commencement of this article, and still much connected with the gun that is of interest to our readers remains to be told. How can any judge of the efficiency of a piece of ordnance till they are informed of its cost, its weight, its durability, its range and accuracy as compared with those of the artillery it is intended to supersede? These are matters which cannot be stated, much less explained, in a few words, and, that they may be laid before the public in a manner which will at least enable them to form an opinion for themselves, we must defer continuing our remarks to another occasion.

The Armstrong Gun.

(Concluded from *the Times*, of the 24th.)

The article which appeared in our columns of Tuesday last merely described the routine of processes followed in perfecting the manufacture of this remarkable engine of modern warfare. But the public, in order to appreciate the value of the invention fully, have yet to learn somewhat of its relative weight, cost, range, accuracy, and the rate at which it can be produced compared with the old-fashioned smooth-bored artillery, in short, all its essential qualities as a working gun. The qualities of course, are the main facts of importance connected with ordnance of every kind; information therefore, concerning them, may not be without interest at a time when the indefatigable activity of the War office is bringing about a scientific revolution even in our old muzzle-loading artillery. Now, as to the rate at which the Armstrong guns can be produced, it has been already stated that the Government, 10 months ago, pledged itself that the united exertions of the factories at Elswick and Woolwich should enable them to complete 100 guns within the last year. Before the close of 1859 upwards of 100 guns had been completed at Woolwich alone, where the work has been so

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constantly and so successfully urged forward that the rate of manufacture has risen from 5 to 23 guns per week. Up to the present time 113 12 pounder field guns are already finished there, and in all 220 are more or less advanced towards completion. All of these are 12-pounders, but as between Elswick and Woolwich a sufficient number of guns of this calibre has either been already manufactured or is nearly finished to re-arm the whole of our field batteries, no more of this size are to be made, and both factories, will in future concentrate their efforts on heavy, or at least much heavier ordnance. Supposing Woolwich to be able to continue at its present rate of 23 a week, we ought to have from this source alone upwards of 1,100 of the new guns before the close of the present year. Allowing for the delay consequent upon the heavy forging of the 25, 40, 70, and 100-pounder guns, as are now soon to be begun, still Woolwich ought and we have not the least doubt, will complete its 1,000 guns before next Christmas. From Sir William Armstrong's own works at Elswick, in addition to a few heavy guns, two complete 12-pounder field batteries have been sent to China with 21 12-pounder guns for boat service, for which from their extreme lightness they are most admirably suited. In addito this, 40 12-pounder guns for the field batteries are ready and only waiting to be forwarded to Woolwich for mounting. Two 40-pounder guns are being made per day; while the manufacture of the heavy ordnance has commenced with a 100-pounder, 10 feet 6 inches gun, which is expected to obtain a range of 6½ miles. Like Woolwich, the Elswick works have risen also in their rate of production, from about three per week to 14, and there is no doubt but that at a pinch, even with their present staffs, Elswick and Woolwich could easily turn out 40 completed guns each week.

To double or even to quadruple this weekly number the War-office would simply have to increase the machinery employed in every stage of the manufacture, which might so be extended to an almost unlimited amount. The rate of pro-

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duction at Woolwich is one gun for every three and a half working hours, and one for each four and a half hours at Elswick. At both places, however, a single gun, from the time the rolling of the No. 1 coils commences till the finished piece is proved and passed examination requires from six to seven weeks of constant and skilful labour. A great deal has been both said and written as to the expence of the Armstrong gun, which it has been urged, is so excessive as almost to preclude its general adoption throughout the services. Such reports are quite unfounded. It is, and always will be, an expensive process to supersede an immense amount of comparatively new artillery merely to substitute in its place a more efficient weapon ; but this is a tax always entailed on progress in any branch of manufacture. Guns of all kinds, no matter whether cast iron, an Armstrong, or a Whitworth, are manufactured solely to attain certain essential results, and the piece which attains these in the greatest proportion must of necessity always prove the most economical in the end. But, setting aside this obvious truism, the Armstrong gun is in every point of view except, perhaps, that of mere first cost the cheapest weapon that has yet been produced. Thus an ordinary 12-pounder field battery gun cost, in metal and labour, about 200*l*. Its utmost really accurate range is 1,400 yards ; its weight is 19 cwt., requiring six horses to draw it in the field. It is capable of firing 800 rounds of shot under favourable circumstances, after which number, if it survives so long it is always condemned and broken up, realizing about half its cost as gun metal. The Armstrong 12-pounder gun costs about 250*l* ; its aim is accurate at much more than 5,000 yards ; its weight is only 8 cwt., and it therefore only requires four horses to move it with the utmost rapidity. Some of those already made have actually fired upwards of 3,500 rounds of shot and shell, and are still new guns. For the number of shots in proportion to the cost of the gun, the old muzzle-loader costs 5s. for every discharge, the Armstrong only 1s. 3d., though the for-

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mer is ineffectual at three-quarters of a mile, and the latter unerring at two. The chief and most important saving however, is in the smaller number of men it requires to work it and, above all, the saving of horse labour. Only those who have seen the difficulty with which artillery is transported with an army can properly appreciate the importance of reducing this the most formidable of all its many impediments. While still retaining the same strength the Armstrong gun could easily be reduced to almost half the weight at which it is now manufactured, but that there are limits to the amount of lightness which is desirable in these guns. The backward recoil of the gun is in exact proportion to the velocity and force with which the shot leaves the breech, and even the 8 cwt. 12-pounder 'kicks' to an extent that may render it necessary to strengthen considerably the present form of carriages for field artillery.

It may sound strange to our readers, though it is nevertheless strictly true, that up to the present time, Sir W. Armstrong has uot manufactured any gun with a view of attaining a long range. The range of all the guns on this principle is of course immense, but Sir William's main and almost only object has been to secure perfect accuracy of aim. That this is attained, to an extent almost incredible to those who have not seen the practice with it, is now admitted even by old artillery officers—the very last and most reluctant to confess that the gun was worth anything at all, or that a civilian could know much more than the difference between the breech and the muzzle of a cannon.

Yet, in spite of this unfavourable opinion, so loudly pronounced at one time, the gunners who are used to the Armstrong declare that with it they would undertake never once to miss a man at a mile; At one of the factories a strip of board is shown, 22in. long by 9in. broad, which, when the gunners were practising was whitened over and put up as a target at a distance of three-quarters of a mile. Though only

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just visible at this great range, it was hit three times in four shots At the Elswick works at Newcastle, a 100-pounder, about 11 feet in length, is being manufactured with almost the express view of attaining a long range. This piece, it is anticipated, will have an effective range over six miles and a half. All these tremendous results it must be remembered too, are accomplished with little more than one-half the charge of powder used with the present muzzle-loading cannon. This is due not only to the size of the shot itself, which allows no windage, and so receives the whole explosive force ofthe powder, but to the peculiar mode and pitch of the rifling. The Armstrong shot is of course conical, and about 2½ diameters in length. At the shoulder of the cone is a ring of lead dovetailed into the iron, and a similar one at the base. These are both made about one-sixteenth of an inch larger than the diameter of the bore of the gun, so that the finest lines of the rifling are filled up, and no windage whatever takes place. With an ordinary muzzle-loading 32-pounder, weighing 56 cwt., it requires 10 lbs. of powder to hit at 3,000 yards' distance. An Armstrong 32-pounder, weighing 20 cwt., only takes 5 lbs. of powder to send its ball nearly 10,000 yards.

About this time twelve months the Government had a very large factory at Woolwich for the purpose of casting the ordinary iron guns, which had previously been mostly obtained from private firms, more particularly from the Low Moor and Gospel Oak works, the guns from which were always considered the very best. Misled by false economy, the Government in an evil hour undertook to compete with the private trade and of course they did so with precisely the same result that has always attended such competition in this country, from the time of Elizabeth's monopolies down to the present day. 90,000*l.* was spent in erecting a factory at Woolwich, which was opened amid a tremendous flourish of trumpets as to what it would accomplish. But at the very outset the Government factory found, to its dismay, that it

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was not in possession of the secret of mixing iron used by the Low Moor people in making their guns, and that in consequence of this trifling deficiency the guns so made at Woolwich mostly burst in proving. Low Moor was courteously invited to impart its secret, which Low Moor, with the utmost sagacity and prudence, as courteously declined to do. So the Government set to work to analyze ores, &c., with a view to discover a secret of manufacturing skill, and much of which also was mainly due to the peculiar coal used at Low Moor-works, which made their castings almost equal to the best charcoal iron. It is needless to say how utterly the attempt to pierce this secret by merely analyzing the iron failed, and, the factory being at last discovered to be nothing more than a most costly and unproductive experiment the Government very wisely determined to put an end to it at once. The gun foundry accordingly disappeared from among the large items in our army estimates, and the whole place was given over to Sir William Armstrong.

Under his care, and backed by the zealous support of the permanent heads of the War-office, the whole of the immense plant and machinery, steam hammers, turning lathes and boring machines were at once converted at small expense to assist in the various processes by which the Armstrong gun is brought to perfection. So carefully and economically has this been done that every single portion of the machinery is now converted to its new purpose at the cost of only a few thousand pounds. Thus, then, as we have said, with this old plant renewed, Woolwich ought this year to turn out at the least 1,000 heavy Armstrong guns and Elswick 650—an immense addition (when the range and accuracy of this formidable artillery are considered) to the defences of the country. In the meantime the War-office is turning its attention towards devising some method by which the immense stores of old iron ordnance may be utilized to a certain extent by rifling them after the manner of the French. How the French have managed to succeed in this process it is difficult to say,

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inasmuch as all the guns that have been rifled in England (and they have been rifled after every known conceivable plan) have all, without a single exception, burst before their experimental trials were concluded. These repeated mishaps turned the attention of inventors in another direction, and it was sought to devise some method to strengthen the cast-iron muzzle-loading guns now lying in thousands in all our arsenals, so as to enable them to bear rifling, and the immense additional shock created by the increased resistance to the projection of the conical shot. To this end a number of ca st-iron guns of the ordinary size have been hooped round with rings of wrought-iron, shrunk on while red hot. The effect of these two inches of wrought-iron outside the cast has been literally to increase the strength of the gun more than four-fold. Thus, a 96 cwt. 68 pounder from Low Moor not unfrequently breaks at the proof charge of 28 lb. of powder and one shot. A gun of exactly the same size and weight, only partly constructed with hoops of wrought-iron, bears a 28 lb. charge of powder, and blows out a long iron roller weighing no less than five cwt. without bursting, and when they have burst under this tremendous test it has always been exactly at the spot where an opening or fissure was left between the wrought iron hoops in rolling them in. These experiments have led the Government to require certain results from all inventions for rifling our common iron ordnance, such as strength, comparative lightness, accuracy in aim, and length of range, though the latter is very wisely placed far subordinate in importance to accuracy. There are now six new inventions under the consideration of the War-office, which all profess to attain, and which all do more or less attain, these essential conditions--viz. a gun of Sir William Armstrong, one by Commander Scott, R. N., one by Mr. Whitworth, one by Mr Lancaster, one by Mr. Bashley Britton, and one by Mr. Jeffries. Which will be the invention eventually chosen, we of course, cannot pretend to say, though it is generally understood that the struggle rests between Mr. Whitworth and Sir William. The former gen-

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tleman has himself invented a breech loading cannon which for strength, simplicity, ranges and accuracy, is said to surpass even the Armstrong; but this point will be set at rest in a few days, when a public trial of the gun will be made near Liverpool.

But, whatever plan is adopted for the conversion of the iron ordnance into rifled cannon, it is known that it must be based upon the principle of hooping it with wrought-iron. The War-office, therefore, is taking time by the forelock, and, pending the decision as to which of the many plans is best, is erecting a splendid range of foundries at Woolwich, for the purpose of working in the wrought-iron bands, while a large number of lathes have been constructed to be ready to proceed at once in turning the shot or shell, which, of course, will be of wrought-iron, and made with mathematical accuracy as to size. All these efforts are very praiseworthy on the score of economy, and also as intended rapidly to place at the disposal of the country a large store of the most formidable kind of guns. But it is a more than doubtful question how far these cast-iron guns are capable of being rifled at all, and it is well known that even with the addition of strengthening hoops only the solid 68's and long 32 pounders can be so treated. There should be no mistake on this head—that we, for the sake of a little economy in working up these old guns, should produce an inferior article at a very superior price. The gun must be above those suspicions of bursting which so unpleasantly attach to all cast-iron guns which have hitherto been thus tinkered, else our soldier and sailors will be more afraid of their own ordnance than of the enemy's.

Of the two greatest breech-loading guns which have yet been constructed—those of Armstrong and Whitworth,—the latter it is said, cannot be burst, while it is certain that no one has ever yet succeeded in bursting the former. So immense, indeed, is the strength of the Armstrong gun, that a piece of iron cut from it at any part bears a tensile strain of

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no less than thirty-three tons to the square inch. It is a gun of such strength as this which is required, and which, if mere economy and the consumption of a large store of very second-rate material is the only object in view, it is doubtful that we may get. The war-office may depend on one thing,—that the only great danger they have to avoid is making any thing approaching to a second-rate weapon from merely economical motives, no matter how great the inducement or how reasonable the hopes of better results. Let them seek only to attain the best weapon which can be obtained under the circumstances, and both the public and our naval and military service are sure to be satisfied. Judging of the future by the past, and looking to the immense results the War-office has already achieved with the Armstrong gun, the matter may be considered to be in the best train, and we have not the least doubt but that the decision it arrives at will be one which the country and the services will endorse. A few weeks will at the latest determine what kind of rifled cannon, in addition to the Armstrong, will be used, when our readers may depend on having early and accurate information on the whole subject. The attention of the public cannot be too often or too strongly directed to this question of the improvement of our ordnance, a question not inferior in national importance to the Volunteer Movement which this journal has done so much to originate and forward The Government should neglect no effort to get, if possible, even a better gun than Armstrong's, and, if that is not to be accomplished, they must turn their energeies to seeing that the country has an abundance of the artillery which their experience has proved to be the best.

The Enfield Rifle.

Some three or four years ago many of our engineers, manufacturers, and scientific men were deluded into going over to New York in the expectation of their seeing an industrial exhibition. Among others so misled was Mr. Whitworth,

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who, like all the rest, finding nothing worth looking at in the exhibition itself, tried to recompense himself for his visit by inspecting those manufactories which most abounded in the labour-saving machines which are used more or less extensively throughout the States. The two great centres for machinery of this description were at the United States' arsenals at Springfield and Harper's Ferry, and these accordingly Mr. Whitworth visited, saw the various processes there pursued of making small arms in thousands by machinery, and reported to our own Government strongly in favour both of the plan of the Government making its own weapons, and the means by which it could best be accomplished. The War-office, on receiving this report, adopted it forthwith, and, to their infinite credit, at once took a step which at the time even the most strenuous friends of progress in their secret souls scarcely approved. They sent out a commission, of which Mr. Anderson, now the chief superintendent of the Armstrong Gun Factory at Woolwich, was at the head, to make further inquiries into the subject of Mr. Whitworth's report, and with power not only to order machines in America, but to engage American engineers to superintend them. This was the commencement of the now famous Enfield factory, and this is the first instance in which the English Government have ever had to send abroad either for machinery or men to work or make it. To their praise be it said they at once overstepped the formidable though narrow boundaries of national prejudice, and looked only for that market in which what they wanted could be best and easiest obtained. For a short time several of the new machines were erected and worked at Woolwich; but, when "Brown Bess" was no longer paramount in the service, it was determined to create an immense establishment for the manufacture of rifled small arms, apart and in itself distinct from the operations carried forward at the arsenal. A small shop, if we may so term it, for the manufacture of gun-stocks had always existed at Enfield, and this led the Government to turn their eyes in

that direction, and, once the place was seen, their gaze was, so to speak, fascinated. It was not at all the beauty of the spot which induced the Government to select it, for, in truth, a flatter or more dreary-looking waste, save Aldershott, was never seen. It was certainly not its salubrity, inasmuch as the whole country is eminently damp and unhealthy; neither was it either its convenience of access or its vicinage to skilled labour, for in both these requisites it was and still is singularly deficient as compared with other neighbourhoods. The reason why the Government selected it was entirely independent of all these considerations of fitness, and due only to the simple fact that near the shop before alluded to was a canal which turned a waterwheel exerting some 20 or 25 horse-power. The idea of economizing and bringing into play this little waterwheel (which has now ten times its power of steam machinery to assist it)settled the whole affair, Foundations were laid and buildings commenced forthwith, and factories the size of little villages sprang up with more than the rapidity of colonial enterprise. Already the nucleus of a small town is fast gathering round the works. Hucksters' shops, workmen's houses, and small hotels are dotted here and there; and it becomes easy now to calculate when, according to the natural course of things, "Ordnance Enfield," as it is called, will some day become a town clamorous for corporate rights and the privileges attaching to its own M. P. And all these changes will be due to an old waterwheel which the Government could have got anywhere, and that, too, without the drawbacks attendant upon a superabundant supply of the pure element which turns it, and which occasionally hides the face of the surrounding country at Enfield, and places the floors of cottages and houses some inches under water. However, we suppose we must not quarrel with any cause which produces an effect so perfect in itself, so economical in its work, and so admirably managed, as the factory at Enfield undoubtedly is. It used to be a general remark, and one pretty generally believed, that Government could never

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compete advantageously with private manufacturers, and, to do them justice, the Government occasionally gave great force to the observation by rashly entering into contests with the trade on most uneqnal terms. At Enfield, however, they have discarded the usual routine. There is no costly system of supervision; on the contrary, every body connected with the place is rather underpaid. The Government only seek there to make their own weapons, and intrusts all the means and appliances to the hands of private engineers of acknowledged, though unofficial, capacity. Mr. Burton, an American gentleman, is the working and real head of the factory, and to his untiring skill and diligence its singular excellence is due.

With such tokens of military ardour as now so extensively prevail throughout the kingdom the Enfield rifle is likely to become not only a household word, but almost a household weapon. At such a time therefore, some account of the manufacture and peculiarities of this most effective, but most easily injured weapon, may be of interest, and, if it does not make our young volunteers good marksmen, it will at least put them on their guard against such careless treatment of their pieces as may put it out of their power ever to hit anything with them smaller than a haystack.

The first thing that strikes a visitor on entering the forges at Enfield where the barrels are made is the apparent rudeness and inadequacy of the machinery to its purpose. It may be urged that it makes the barrels very well, but the same excuse might be advanced for non-improvement in every stage of manufacture, and we are sure that among the clear-headed American mechanists now at the works are many who could at a day's notice devise a far better apparatus for working up the iron of the barrels than that now in use. The materials for the barrels are brought to the factory in short square slabs of wrought iron (with the fibre of the metal crossing and recrossing at right angles,) each some 12 inches long by 4 broad, and half an inch thick. These are

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heated and bent into a short tube having somewhat the appearance of a rough and ill-made draining tile, and in this state are again heated to a bright white, and passed between iron rollers of the first gauge, which weld up the joining down the middle, and, by compression, lengthen the tube about $2\frac{1}{2}$ or 3 inches more. It is again heated, and again passed between rollers of a smaller gauge, which lengthens it still further; and so on, again and again, until the operation has been repeated through 13 different gauges, when the rolling is complete, and the barrel—after some two hours' manufacture emerges at last a slender rough iron tube about four feet long, and having a hole down the centre the size of a large pea. The muzzles are then cut off, the "buts," or ends, as they are termed, made up, and the process of welding on the "cone-seat," or nipple for the cap, commences. This latter is a difficult operation, and one which requires no little quickness, care, and skill on the part of the workmen. To insure rapidity of striking while the metals are red-hot, the breech of the barrel with the cone-seat is placed in a steel die under a small hammer worked by steam, which strikes at the rate of 400 blows a minute, and under which, amid a terriffic din, the metals are crushed together, with more than the strength of one piece.

This completes the forgings, and the barrels are passed from the smithy to the boring shops, where the operation of boring (exclusive of rifling) is repeated no less than five distinct times. The barrels are for this purpose laid in horizontal machines, and the first sized borer is *drawn* up through them, not *forced down*, as, from the bend of the boring bit in forcing it through, it was found difficult to secure strict accuracy. The second boring at swift speed is then continued, and the third at slow speed, by which time the barrel is finished to within some two or three thousandths of an inch of its proper diameter, when the exterior is turned down also to its service size. The operation, if such it may be called, of straightening the barrel is then gone through after

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the screw-hole for the breech-piece has been bored. This straightening is one of the roughest and most unsatisfactory portions of the whole process of manufacture. From the very fine soft nature of the iron used in the construction of the barrel, and the extreme thinness of the metal itself, the least violence or concussion is apt either to bend the barrel outright, or else to put such a dint in its side as effectually makes an end of its good shooting. Thus, in the processes which we have already described, in spite of the utmost care, the barrel is supposed to have deviated from its true line sufficiently to require considerable rectification. This rectification is done, therefore, not by machinery, but by hand, a workman looking through the barrel and giving it a tap here and a tap there with a hammer, wherever it seems to him to require it. In defence of this apparently very rude method, which seems so astounding in connexion with a bore that must be accurate to the thousandth part of an inch, the managers of the works point to the results achieved, and say that out of some 2,000 weapons made weekly the gauge of all is accurate to a half-hair breadth. This undoubtedly is true, but it is neverthless very far from proving that such mathematical exactness is brought about by a man simply looking through the barrel and giving it a knock now and a knock then whenever he fancies he by sight detects an inequality in it. Most practical mechanics are of opinion that the process either does no good to the barrel at all, or that its results, if worth anything, would be better and more easily accomplished by machinery.

An immense variety of milling and grinding stages are next gone through, which merely relate to the exterior of the barrel, and with which, of course, we need not trouble ourselves here. A detailed account of the whole manufacture would be out of the question, as our readers may easily imagine, when we say that the barrel undergoes no less than 66 distinct processes, and the whole rifle upwards of 700 ere it is completed. The barrel, then, having so far advanced

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in its progress towards completion as to be bored for the fourth time, it undergoes its first proof test of nearly one ounce of powder and one ball. Not one per cent, of the barrels yield under this trial, which has sometimes, in the case of doubtful barrels, or those which it was *wished* to burst, been carried to as high a charge as 2½ oz of powder, and 17 balls—the whole barrel full, in fact—before the metal ripped. After this the nipple-screw and nipple, with the "tang" or tongue which fastens the barrel to the stock, are made, though not a single piece is put together till the whole musket is complete to its minutest detail. Before the barrel leaves the boring-room it is again bored out for the fifth time, and, having been polished by machinery inside and outside till it shines as bright as silver, it at last reaches its 56th stage of manufacture, and is taken to the finishing shop.

With the exception, perhaps, of the Laboratory at Woolwich, it would be difficult to name any factory room in the kingdom, not even excepting our largest cotton mills, which at the first glance presents such a bewildering scene of active, never-ceasing industry. Let our readers imagine, if they can, a single room more than an acre in extent, lofty and well lit, in which some thousand men and boys are incessantly employed in superintending machinery. The ear is pained by the hum of fly-wheels, which revolve in thousands till the eye is giddy with their whirl. Miles of shafting are spinning round mistily with a monotonous hum, the room is almost darkened and the view completely obscured by some 50,000 or 60,000 feet of broad flapping lathe-bands, which are driving no less than 600 distinct machines, all going together on their own allotted tasks, with a tremulous rapidity and ease that seem to swallow up the work like magic, and the first sight of which is inexpressibly astonishing to the spectator. It takes some minutes before the visitor can subdue the overwhelming feeling of surprise which this scene of activity always excites, no matter how often entered on. Following the barrel, then, but with care, into this

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maze of lathe-bands, we see the process of rifling first commenced. The rifling in the Enfield barrel consists of three broad shallow grooves, with a pitch of half a turn in the length of the barrel of three feet 6 inches. The depth of the rifling is 0-5 at the muzzle, and 0-13 at the breech, the width of each groove being 3-16ths of an inch. There are 16 rifling machines at Enfield, each of which turns out 26 barrels a-day, though, of course, the grooves are made separately, and after the same fashion as in the boring—viz., drawn through the gun from the muzzle to the breech. Looking at the light through a newly rifled barrel has an extraordinary effect, the rings of reflected rays showing like bars of black and white metal alternately; and by the aid of these, as it is said, the workmen are able to distinguish whether or not the tube is perfectly accurate.

After the rifling it is again proved with half an ounce of powder and a single ball; when it is retouched, sighted, trimmed-off, milled, levelled, browned, and gauged, coming out in the gauge-room at last a finished barrel, made to such perfection of accuracy that the steel gauge of 577 thousandths of an inch passes freely through, while that of 580 sticks firm in the muzzle. Browning, as we have said, is the last operation which the gun undergoes, and this merely ornamental process occupies a week more than the whole manufacture of the gun itself—namely, four weeks. The time thus bestowed, however, is not without its value, inasmuch as after the "browning" is completed, though not till then, the gaugers are enabled to detect the slightest imperfect welding or least perceptible flaw of manufacture, when the piece is instantly rejected, and the workman under whose hands the flaw took place fined 3s., no matter whether the imperfection is discovered at the very commencement of the process or when all is finished. The barrels thus flawed, we regret to say, are sold as old iron, but still in the form of finished barrels, and so doubtless find their way back again into the market as proved pieces. Than this latter arrangement of selling the

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barrels complete, though as old iron, nothing can be more objectionable, and we are sure the War-office only require to have their attention drawn to the matter to secure for the future that all such pieces, before they are sold, shall be bent and flattened in such a manner as to be totally useless, at least for gun barrels, ever after.

But, as we intimated at the commencement of this article, the long processes by which the Enfield is brought to completion cannot easily be disposed of in a notice like the present. We defer, then, to a future occaison our description of the other portions of manufacture and the peculiar weaknesses which render this weapon above all others so liable on slight occasions to irreparable injury.—*Times.*

The Enfield Rifle.

(*Concluded.*)

In the first article on this weapon we traced the manufacture of the most important portion, the barrel, up to its final completion, when the gauge is placed in its muzzle, and proves such a perfect mechanical fit that it remains bobbing up and down, according as the column of air in the tube yields or expands beneath the pressure. Will Birmingham, where all the anvils are now resounding with the manufacture of rifles for the Volunteer Corps, turn out a weapon as perfect in its gauge as that of Enfield? We can only hope so, for, if not, the Volunteers will be but poorly off when they come to be supplied with ammunition, made by the Government with the same care as to size as the barrel itself, and which should fit with almost the same nicety as the gauge we have mentioned. At Enfield everything is done by machinery, as we have already pointed out, and so each portion of the lock, stock, bayonet, and fittings of the gun is manufactured by the same kind of labour saving machines as those employed upon the barrel. The part of the works devoted to this portion of the manufacture is filled with a peculiar

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and most ingenious modification of the pile-driving machine, where the weights are wound up by steam, and are ready for dropping again and again at the precise time required by the workmen in each stage. These weights punch out the hammers, lock plates, springs, triggers, bands, and, in fact, every part of the gun or its fittings which is made either of iron or steel. After being thus roughly formed they are turned down to their exact size, according to gauge, and then case-hardened. This latter process is done by heating the parts to a dull red in a mixture of bone-dust (animal charcoal, in fact,) so that the outside of the metal has all the hardness of the finest steel, while the centre retains the strength and toughness of wrought iron. The bayonet is, of course, manufactured at Enfield, with the other parts of the complete weapon, and nearly all the 68 processes which this piece undergoes are very interesting. Take it for all in all, no troops in the world are armed with such a strong, well-tempered, and efficient steel instrument of destruction as the bayonet which is issued to our troops. It is very much to be wished that the cavalry sabre at all approached it in either temper or strength, or that it had never been surperseded by the cumbrous und inefficient sword-bayonet, which is only a bad and very heavy sword when off the rifle, and neither a sword nor a bayonet when on it. When the bayonets are first beaten out at Enfield they are as brittle as glass; they are then annealed in a slow fire, and become as soft as lead. While in this state they are subjected to the last chief process, that of tempering, which gives them that immense strength and spring which is found in no other weapon. The tempering is done by immersing all the blades in a bath of molten lead, which heats them to a dull red tint, when they are withdrawn and plunged into linseed oil, becoming then so hard again that the file makes no impression whatever. They are then again heated to a low temperature, and this perfects them as steel. A man then tests them as to their strength by striking them with the handles downwards over

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the hedge of an anvil with all his force, after which they are forcibly bent backwards and forwards in a machine, and finally gauged, Those which have yielded under these ordeals, even to the very slightest degree, are rejected; the rest pass on to the grinding shop, where they are polished and finished off bright and keen as razors. The cost of each of these bayonets to the Government, even including interest and wear and tear of plant, is only 3s. 6d. They could scarcely be made elsewhere at any price whatever. In making the stocks of the rifles the machinery employed is about the best and simplest that has ever been devised, and from the time that the rough beam of walnut-wood enters the row of machines at one end of the finishing-room till it comes forth at the other end a perfect stock, complete even to the most minute receptacles for the lock-work, the process occupied not quite 20 minutes. If there is any part of the manufacture in which a saving of time and labor might possibly be effected, it would certainly be in the gauging. Not only is every portion gauged in every process, but when all is done each is gauged and regauged again by half-a-dozen independent measurers one after the other. The result of all this is, that the very perfection of a mechanical fit is insured, and all parts, whether of stock, lock, or barrel, are interchangeable among all the Enfield rifles in the service. For the sake of this advantage alone, and exclusive of the undoubted superiority of manufacture, it would be well worth the while of Volunteer Corps to pay even a higher price in order to secure the Government rifle. The cost of each one to the Government is 2*l*. 5s., and they are produced at Enfield at the rate of 2,000 a-week. A perfect musket and bayonet are turned out there every two minutes, though from the time the processes commence with a single musket until it is finished, proved, and passed to store requires a period of seven weeks—of which, however, no less than four are occupied in "browning" the barrel. As with the manufacture of the Armstrong gun so with the Enfield, its rate of production is capable, at a short notice, of

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being extended to an almost unlimited amount by merely increasing the machinery employed in its manufacture. It swallowed up very much more than 200,000*l.* to enable the Enfield works to produce the number they at present do weekly. Less than 80,000*l* expended in increasing the plant would now, however, give the existing factory the means of turning out 5,000 rifles a week, while 80,000*l.* in addition to this again would suffice for the production of nearly 10,000

The weak point of the Enfield rifle is exactly that part which ought to be the very best and strongest of the whole—viz., the barrel. This, from important consideration as to lightness, and from the softness of the wrought metal itself, is too thin and too yielding to be subjected with safety to the rude chances of a campaign, unless the soldier is taught to be particularly cautious as to its use. A very trifling injury as compared with that to which all other barrels are subjected with impunity is enough to dint and injure that of the Enfield to the most serious extent. Our readers must remember the large number of Enfield rifles which during the late canpaigns in India were found to be inefficient from becoming suddenly too small at the muzzle to admit of the bullets entering. It was afterwards found that in some cases from so slight a cause as the unequal thickness of the paper in which the bullet end of the cartridge is inclosed. This, however, was only the case in a few instances, the great source of injury, it was supposed, being the rough manner in which the soldiers "fixed bayonets" over the muzzle, or the careless manner in which the piece was handled with the bayonet on,—an almost imperceptible knock under such circumstances sufficing to dint the muzzle and prevent the entry of the bullet. Unless the most rigid caution is used, how much more likely are these injuries to occur among the weapons of Volunteer Corps, the muzzles of which instead of carrying a 13-oz. bayonet, are all hampered with the so-called sword bayonet, weighing some three and a-half pounds! This latter cumbrous appendage, in addition to

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its thousand other disadvantages, has, when fixed in firing, a most serious effect on the accuracy of the bullet itself, over which it exercises nearly 3 times the amount of adverse influence that is attributed to the bayonet in the same position.

Two remedies have been proposed for doing away with this deficiency in strength of the Enfield barrel. One method is to make it entirely of Whitworth's homogeneous iron, and the other is a plan of Mr Burton's to make the barrel of steel. Each change would be a great improvement, the latter perhaps the greatest if there did not exist such difficulties in the way of welding on the "cone seat" after the barrel has been rough-made. Another mode of improving the barrel, by which all experience shows that an increase of range, and therefore of accuracy, could be gained, would be to alter the pitch or turn of the rifling. All firearms are rifled in order to ensure a regular and steady flight of the projectile by giving it rotation round its axis of progression. The Enfield has only half a turn in the pitch of the rifling in the length of the whole barrel, and this, it is generally believed, might be increased to one complete turn with the most favorable results. In the course of the many valuable experiments which Mr. Whitworth made as to the best pitch of rifling, in order to try the effects of the bullet of extreme velocity of rotation in the barrel he actually made one with one complete turn *in the inch*,—in fact, the inside of the barrel was a perfect screw. Yet this barrel, charged with 25 grains of powder, fired a perfectly fitting ball of lead and tin through seven inches of elm planks. The same gentleman, with a 24-pounder howitzer, having a hexagon bore, and, of course, a hexagon projectile on his own plan, fired with low charges shells of 10 diameters in length. With projectiles of a greater length than that of the common Enfield ball fired from the Enfield rifle, the bullet, no matter what its shape, always turns over within 6 feet from the muzzle of the piece, the rotatory force given by the slow turn in the barrel being insufficient to keep

the conical ball point foremost. Mr. Whitworth proposes that all military barrels should be rifled with one turn in 20 inches, and even those most opposed to adopting so rapid a pitch consider that the present pitch of the Enfield might be increased with great advantage. The Whitworth rifle, on the principle of the hexagon bore and hexagon shot, and with the increased pitch we have mentioned, has in all Government trials that have yet been attempted beaten the Enfield both in accuracy and range, and of course, therefore, in penetration. It may, under these circumstances, be asked, why then is it that the Government have not adopted it and commenced its manufacture, especially as the present machinery at Enfield could be altered to suit the new plan of boring at a cost of not more than 50*l* or 100*l*? On this point we are free to confess that we see no valid reason whatever why the Government have not adopted it. The excuses urged against the adoption are, first, that the Government having so lately incurred the expense of altering all the weapons in the army, from the "brown bess" to the Minie, and from the Minie to the Enfield, are not now prepared to meet the cost of altering them again, especially as during the next two or three months a breech-loading plan is likely to be adopted, which it is said may exercise a most important influence on the form and nature of the barrel to which it is applied.—*Times*.

Trial of Mr. Whitworth's Rifled Cannon.

(FROM OUR OWN CORRESPONDENT.)

SOUTHPORT.

The first experimental trials of the ranges and accuracy of Mr. Whitworth's breech-loading cannon, having the peculiar hexagonal bore and firing the long six-sided cone, which form the basis of that gentleman's principle of rifled ordnance, were made here during yesterday and to-day. The results, which have been so long looked forward to with eagerness by Artillerymen and Engineers, surpassed the

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most sanguine expectations. The success, in fact, was really astounding. The accuracy of fire and length of range obtained from trifling charges of powder were so totally beyond what has ever yet been attained that it is evident we are upon the eve of another revolution in all relating to scientific gunnery, and that even the greatest results which have ever been obtained from the Armstrong gun are likely to be in turn surpassed by Mr. Withworth's ordnance. It is a very general though not the less an erroneous opinion to suppose that each great improvement is to be the last of its kind, and thus with the manufacture of Armstrong's admirable cannon, possessing such qualities of range, accuracy, and penetration as to be removed from any degree of comparison with the old ordnance, it was thought that the *ne plus ultra* of gunnery had been attained, and that further improvement was hopeless. The truth is, however, that in beginning with a rifled breech-loader we have merely made the first step in an entirely new path, which may lead to effective results even yet considered beyond attainment. It is only within the last two or three years that scientific men have at all directed their attention to the laws which govern the flight of all projectiles, and have studied the mechanical condition which these require in the form of shot and rifling of gun. The Armstrong gun was a gigantic stride in the progress of scientific gunnery, but the experiments which have just been made at this place show that it is not the last we must expect, and that, though at present greater than all others in range and precision, even the Whitworth gun in both these points may be surpassed by others before the year is out.

Mr. Whitworth's cannon have, of course, been made entirely at his own expense, as that gentleman wished to work out his system as applied to rifled ordnance independently, and to show by practical results that it possessed these advantages which his mechanical knowledge led him to predicate, and which his success with his rifled musket justified him in anticipating.

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The Whitworth bore is now so well known that it is scarcely necessary to say it is hexagonal in section, the corners being rounded off, and the interior of the barrel may be generally described as being a hollow polygonal spiral. The degree of twist depends on the diameter of the bore, and is always sufficiently rapid to compensate for any length of shot which may be fired, on the principle established by Mr. Whitworth, that unsteadiness in long projectiles may be counteracted by rapidity of rotation.

The guns are, of course, all made to load at the breech. The first impression created is one of surprise at the extreme simplicity of their construction, and the consequent ease and certainty with which they are worked, as will be apparent when that operation is described.

As the guns are all alike in every respect but proportions of size, a description of one will suffice. The piece may, in familiar terms, be said to consist of a tube rifled throughout from muzzle to breech; the breech is closed, when the gun is loaded, by a cap, in shape something like the cap of a telescope. The cap is fitted on the breech end of the tube, which is screwed externally to receive it. It is never wholly removed like the breech-piece of an Armstrong, but turns and works in an iron hoop, which is connected with a projection at the side of the breech by a hinge joint, on which it swivels sideways. One great advantage of this plan of construction is that it enables the whole length of the barrel to be rifled, and thus every inch of it becomes effective as a gun, which is not the case when a chamber or other breech-loading apparatus, as in Armstrong's for instance, occupies the breech of the piece.

Supposing, then, the gun to have been fired, a description of the operation of loading and discharging will explain the construction and action of the breech-loading apparatus. By turning a handle fitted on the cap the latter is unscrewed from the breech and turned back, and being supported always

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by the hinged hoop, is, when open, turned with it on one side, leaving the tube open from end to end. The projectile is then placed in the gun, the powder-cartridge is pushed in behind it, the breech-cap is shut like a door into its place, and, while the hinge supports it in a proper position, three turns of the handle screw it on to the end of the piece. It is, in fact, a breech on a hinged hoop, which shuts and then screws on. The touchhole is fixed in the centre of the breech cap at the back, and is, therefore, in line with the axis of the piece. The gun is, therefore, fired by the ordinary friction tube, and, though no trial of speed has been made, it can, we think, be fired rather more quickly than Armstrong's. Before referring to the shape of the projectile and the cartridge, it may be as well to state that all Whitworth's guns are made of a mass of homogeneous iron, bored out of the solid piece. The larger guns, such as 80-pounders, are strengthened by wrought iron-hoops, forced on by hydraulic pressure. Self-acting machinery is employed in making all the guns, and the operation is thus cheaper and more economical than forging.

One of the most important and distinctive features in Mr. Whitworth's system of rifling relates to his projectiles. These are simple, uncoated, hard metal bolts, made of various shapes, according to the purposes for which they are employed. They are made by self-acting machinery, and are so shaped that their bearing surfaces fit the interior of the barrel, and it may be said that the rifling, therefore, is done by machinery in the workshop, and not by the explosion in the gun.

For firing through soft substances and into masonry, tubular projectiles are employed; for piercing thick plates of wrought iron, flat fronted projectiles, made of homogeneous iron, are used. We believe that a series of experiments are shortly to be made at Chatham by the direction of the Admiralty with the view of testing the powers of the Whitworth projectile in penetrating wrought iron plates.

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It remains to say a few words as to the cartridge used by Mr. Whitworth. For ordinary practice, and where length of range is important, the fore part of the projectile is made to taper slightly, the front being rounded off, and the rear part is made nearly to correspond with the fore with regard to the degree of taper, but its end is flattened, and sometimes slightly hollowed out. The importance of establishing a proper relation as to shape and relative weights of the fore and hind part of a projectile is apparent from the fact that a projectile which is so made gives an increased range of more than 25 per cent. as compared with one with a similarly shaped front and the ordinary cylindrical rear.

This increase of range is due entirely to the shape of the projectile, as the charges and other conditions of firing are exactly alike, and may be said to be obtained by applying to projectiles moving through the air the proper principles of construction, exactly as a ship constructed with proper lines to facilitate her passage through the water attains the greatest speed.

The powder is contained is cases or cartridges made of tin-plate, which are shaped to fit the rifled interior of the barrel. The base of the powder cartridge is pierced centrally, and its orifice corresponds to the touchhole made in the breech-cap, so that the flash from the fuse reaches the powder. The front of the cartridge is closed with a wad or cake of lubricating substance. This wad forms another important feature in the Whitworth system, as it effectively distributes the lubricating substance over the interior surface of the gun and obviates all necessity of sponging out the barrel.

After the piece is fired the powder-cartridge case remains in the gun, and when the breech-piece is unscrewed and swung aside the case is withdrawn, and with it the fouling deposits left by the explosion of the powder.

Thus much for the general principles of the gun. It only remains now to show the results which they achieved.

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Southport, a small and not very well favoured watering-place, about midway between Manchester and Liverpool, was the spot selected for the trial of the guns, and it would be difficult in all England to find another better suited to the purpose. The whole coast-line for about 20 or 30 miles is a perfect dead level of muddy sand—a cheerless howling wilderness. Nothing bigger than a wrecked starfish or derelict mussel occurs to break the flat monotony for miles, saving always when above high-water mark the wind has carried and chased the sand into small hillocks, the abrupt little peaks and crumbling sides of which are fringed with a thin and sickly weed called "star grass." The weather during the last two days has done much to enhance the naturally uninviting aspect of this place; the shore as the tide recedes is thinly coated over with plashy ice, and the snow, though disdaining to make a permanent lodgment in such an inhospitable region, has condescended to alight in patches here and there, giving, if possible, a colder and a wilder aspect to the shore; but, notwithstanding the present inclemency of its appearance, Southport offers unrivalled facilities for practice with long-range guns. Mr. Whitworth could not possibly have found a better place for testing the merits of his weapon. In facility of approach, retirement, and length of range, it is infinitely superior to Shoeburyness. The Admiralty, we understand, gave Mr. Whitworth leave to practice along this shore, and freely offered him every facility in their power for conducting his experiments. The proprietor of the sand hills before mentioned also in the kindest manner offered him every assistance, and allowed him to enclose whatever length he thought proper. The guns were placed on the shore, between the rough sand downs on the left and high-water mark, some two or three miles below Southport. The 18, 12, and 3-pounders were together. The 70, 80, 90, or 100-pounder gun—for, though its best practice is made with an 80lb. projectile, it is equally fitted for throwing those of the weights we have said—was placed in rear of the rest, mount-

ed on an ordinary ship's gun carriage. The others were properly mounted, on carriages similar to, though both stronger and lighter than, the ordinary field-service gun carriages. This difference of mounting enabled the light 3-pounder, which was especially tested, to be elevated to a most considerable angle, while the 80-pounder, as it ought to be called, could only be tried at an elevation of five degrees. Each of the guns presented much the same appearance as those of Armstrong, except the 80-pounder, which was heavier, because made, in our humble judgment, of an unnecessary thickness, in order that it may eventually be tested up to the most severe charge of powder and weight of projectile. This gun weighs four tons; the Armstrong 100-pounder is only to weigh 2½ tons, which, in point of weight, gives a decided advantage in favor of the latter weapon. It is, however, merely fair to state that, while securing every necessary degree of strength, Mr. Whitworth might easily, we should think, reduce the weight of his 80-pounder to 60 cwt., though with very heavy guns the advantage of comparative lightness remains with Armstrong. With any thing under 12-pounders the Whitworth's, from the nature of their manufacture, can be constructed of such lightness, and, at the same time, of such strength, as, in these respects, to surpass Sir William's best guns of the same low calibre. As all the ordnance used at Southport have only been made for firing and experimental purposes, they are not finished off exteriorly with the same elaborate care displayed in the breech-loaders turned out from Elswick or Woolwich. The difference, however, is merely external, for to a practised eye both weapons display the same careful workmanship in essentials, and the same perfection of manufacturing skill.

At the first glance it is difficult to realize the fact that the 3-pounder—the long, thin tube, like a telescope on wheels, and only weighing 208lbs.—can really be one of the most formidable engines which the science of modern warfare has produced—a terrible weapon, capable, with a charge of powder

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not very much greater than is used in a large duck gun, of dealing almost certain death at a distance of five miles. As compared with the bluff, thick, flat muzzled service gun of a year ago, both Armstrong's and Whitworth's guns seem almost to be animated by an instinct or intelligence of their own; and nothing would more forcibly illustrate the triumph of mind over matter than to see the cumbrous mass of iron now called a 68-pounder placed side by side with a Whitworth 3-pounder tube, capable of destroying its ponderous antagonist at a distance of 10,000 yards! The first experiment was made with the 80-pounder, in order to show the revolving motion given to the projectile by the increase in the pitch or turn of the rifling. For this purpose the gun was loaded with only 8 ounces of powder and one long conical shot of 90-lb. weight. With any other cannon such an insignificant explosive charge would have failed to move the long mass of iron placed over it. With the Whitworth gun, however, the ponderous shot was expelled at a low velocity with a peculiar roaring hum, which was due to the revolution on its own axis as it ploughed through the air, falling at a distance of about 700 yards from the spot. On striking the earth it ricochetted to a considerable elevation at right angles with its line of flight, falling towards the sea amid a shower of sand and water scattered high into the air.

The firing with the 12-pounder field gun was then commenced. The range, as at Shoeburyness, was marked out by tall thin poles placed 1,000 yards apart for a total distance of 10,000 yards (about six miles,) having short sticks placed in the road at every hundred yards between the chief poles. The day was fine, and, though rather dull at the commencement, cleared up towards 1 o'clock. Still, for the immense distance to which the range extended, it was difficult to see anything at all beyond the pole which indicated 4,000 yards, though, as each was fixed in a precise line behind the other, the gun had only to be laid with a proper degree of elevation to reach the most distant point. With the 12-pounder,

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however, no experiments have yet been made expressly to test the range, and yesterday a six-feet target with a two-feet bull's eye was hoisted at 1,000 yards, to show the accuracy of its fire. Two shots were allowed to lay the gun and find the range, the second of which passed between the target and the pole which held it. Of the eight which were then fired all went through the target within a space of four feet square and two through the bull's eye, which, from the place where the gun was fired, looked scarcely bigger than a man's hand. In this result there was nothing astonishing to those who have seen the Armstrong fired, or even the very best practice made now and then with smoothbored field artillery. The charge was 28 ounces of powder, the service charge for an ordinary gun of the same calibre being 56 ounces. With the 28 ounces, however, the force and velocity of the shot seemed enormous; the flight was low, the ricochet very great, and nearly always to the right, in the direction of the pitch of the rifling. One shot, after passing through the target, first grazed the sand at 2,200 yards, then again at 3,000, after which it went on ricochetting along the shore, touching it every 200 or 300 yards, until it buried itself 5,600 yards from the place where it was discharged. The elevation of the gun was 1° 28′ at which the recoil was very little, the explosion much less than that of an ordinary field-piece, and the noise occasioned by the flight of the shot comparatively very slight. One man served the gun with the utmost ease, withdrawing with screw nippers the tin cartridge case from the breech after each shot. No sponging or cleaning of any kind took place, and though, of course, the smut of the powder was in the barrel, the gun was, to all practical intents and purposes, as clean after the firing was over as when it first commenced. There was no heating worthy of notice either at the breech or muzzle. The screwpiece of the breech scarcely ran with the ease which it should have done, but these drawbacks should not enter into consideration just now, as yesterday the guns were tried almost for the first time, and especially with the view of find-

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ing out a working deficiency. The very slight stiffness of the screw simply arose from the fact that the little lever handle used to work it was too short, and was not weighted at the end as the lever handle of the Armstrong is. It is hardly necessary to say that these are mere matters of detail in finish, which can only be ascertained by practice, and which, when known, are remedied in an hour. Another matter which requires alteration relates to the copper fuze friction tube, which, when the gun goes off, is, as with all guns, blown out of the touchhole in the breech. In these guns, however, as we have shown, from their peculiar construction, the touchole is in the middle of the back of the breech, so the copper tube is ejected backwards in a line with the gun with considerable force. This inconvenience Mr. Whitworth is preparing to remedy by a means of catching the tube as it is blown out. When 10 rounds had been fired, with the results we have stated, from the 12-pounder gun, the light 3-pounder was run forward by two men, and practice was commenced at the pole at 4,000 yards, or very nearly two miles and a-half distant. This range is constantly *attained* by the 68 and long 32 pounders in the service, when they get an elevation of some 25 or 30 degrees, and are charged with 10 or 16lb. of powder. The range of 4,000 yards, under these circumstances, is, as we have said, often *attained*; but practice at a mark at such a distance is never heard of. The length of Whitworth's 12-pounder, we should have mentioned, is about 6 feet; its bore nearly 3 inches; and the pitch or turn of the rifling the same as that of all his light guns, namely,—one complete turn in 40 inches; or, roughly speaking, the shot makes nearly two complete revolutions on its axis before it leaves the gun. The bore of the 3-pounder is about 1 ½ inches diameter; its rifling, of course, is at the same pitch, but the length of the gun being shorter—about 5 feet 2 inches—the shot is not turned so much before it leaves. Practice, then, with this 3-pounder commenced with 10 degrees elevation at 4,000 yards, the charge being

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only *seven ounces and a half of powder.* The working features of the gun were the same as we have noticed in the 12-pounder, except that one man worked the gun with much greater ease, firing it without the least attempt at hurry, four times in less than four minutes. The sound of the projectile also was scarcely audible. The first shot fired entered the sand at 4,171 yards distance, and only six yards to the left of the line; the second struck at 4,179 yards at only four yards to the left; the third at 4,224 yards, and five yards to the left; and the fourth at 4,122 yards, at two yards from the line.

The elevation was then altered to 20 degrees, the same charge of 7 ½ ounces being continued for the range of posts from 6,000 to 7,000 yards distant. The first shot at this tremendous range struck the sand at 6,760 yards, and only five yards to the left of the true line. The second struck at 6,784 and 12 yards from the true line in the same direction; the third, at 6,720, was 16 yards out of the line. This deviation to the left was contrary to the usual deviation of the gun, and arose from a rather strong wind which had set in from the sea. The gun was therefore laid more to the right, and threw a fourth shot 6,910 yards' distance, and only two yards to the left of the t.ue line! The charge of powder was then increased to eight ounces, and the elevation of the gun raised to 35 degrees. The practice then made was really extraordinary. The first shot alighted in the sand at 8,970 yards' distance, only 22 yards to right of the line. The second fell at 8,930 yards, and only 10 yards left of the line; the third at 9,059 yards, 10 yards to the right; and the fourth at the immense range of 9,164 yards and 22 yards to the right. Midway between the guns and the target the flight of the projectiles over head could just be heard, and no more.

The 80-pounder was then loaded at 5 degrees elevation, with 12lb. of powder, with which charge it threw a 90lb.

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projectile, with a fearful roar, a distance of 2,550 yards, when it ricochetted at right angles and buried itself in the sea at an immense distance. A second shot, with the same charge, first grazed the sand 2,620 yards distant from the gun, and only two to the right of the true line. From this point it glanced upwards, but continued a straight course onward, alighting in the sand at a distance of over 6,000 yards from the gun. Had this piece been mounted so as to permit of it being fired at a high degree of elevation there is not the least doubt but that it would have thrown its ponderous shot a distance of 8,000 or 10,000 yards, a distance that has never yet been gained by any gun with a projectile of such weight.

To-day Sir John Burgoyne is present at the experiments, which give the same astounding result as those of yesterday, but our notice of these must necessarily be deferred to a future occasion. The greatest trial of all takes place on Wednesday next, when the 80-pounder will be mounted on a stand that will admit of its being fired at any elevation. This trial, from which great results are anticipated, is looked forward to with the deepest interest.—*Times.*

Whitworth and Armstrong Guns.

Since the great success of the Whitworth gun was first published in this journal, that gentleman has continued to demonstrate the scientific principles on which his ordnance are constructed by eliciting from fresh experiments a regularly progressive increase of range and accuracy. Mr. Sidney Herbert has therefore stated in the House that as the Whitworth guns had exceeded the Armstrong in range, and very nearly, as far as could be judged from the rough experiments, equalled it in accuracy, the Government were prepar-

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ed to take the usual steps to give both a competitive trial at Shœburyness. This very fair decision of the War-office has given rise to some dissatisfaction among many of the supporters of the Armstrong gun, who allege that Mr. Whitworth has only obtained greater range by reducing the diameter of his projectile, and, of course, therefore, the bore of the cannon itself; quite forgetting that, as long as that gentleman can prove that a great improvement is brought about by the adoption of certain principles, the public and the military authorities will care very little whether the principles themselves are new or old. By Mr. Whitworth's plan of reducing the diameter of the shot, and therefore the bore of the gun, he contends that not only are the range and accuracy increased, but the gun itself can be constructed of the same relative strength of metal though nearly two-thirds lighter than the ordinary brass guns. The value of this reduction in weight, by allowing fewer horses and fewer men to manœuvre heavier guns at greater speed, must be apparent to any one, more especially to those who have seen what a very little way the largest transports in the service go towards transporting two or three ordinary field batteries, with their present complement of 21 waggons and carriages, 250 horses, and some 250 men. The celebrated three-pounder gun of Whitworth, with carriage and limber complete, could be brought into action and manœuvred and served with the utmost rapidity by two horses and two men only. In this respect, however, the Whitworth gun has no advantage over that of Armstrong; on the contrary, as far as we have yet seen, the Armstrong large guns are much lighter. It has been stated as a kind of objection to the almost astounding results both for range and accuracy which Mr. Whitworth obtained at Southport with such small charges of powder, that Sir William Armstrong had only constructed his ordnance with a view to securing accuracy, and that had he chosen to construct a gun for range alone he would have distanced Mr. Whitworth in that respect. In the articles on

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the manufacture of the Armstrong gun, we pointed out the futility of the difference which is sometimes sought to be drawn between the terms "long range" and "great accuracy," when in truth they mean one and the same thing. Guns are only made with one object, which is, after all, that of throwing their shot in the straightest line, and it therefore of necessity follows that the gun which can send its shot furthest in a straight line secures the greatest accuracy by attaining the greatest range. To suppose that any ordnance can be made for long range and not attain certain accuracy also is to suppose it possible that the more a shot deviates from a straight line, the greater will be the distance it can eventually accomplish,—a proposition which we think few will venture to support. Sir William Armstrong himself, however, is far too experienced a gunner to have suggested this difference between range and accuracy which has been so hastily advanced by some of his many admirers. He states that beyond a certain distance, range for general purposes has no practical value, and that as for artillerymen firing in the field at objects five miles distant, without any clue to guide them but their eye, they might as well fire at the moon. It is not only a question of which shot goes furthest, but what the shot effects when it does reach the mark. The formation of his gun, he states, has not been his chief or only object, which, in fact, has been as much directed to inventing the most destructive projectile.

To secure this all-important object, he has been compelled to give up to a certain extent the attainment of an immense range, and increase the diameter of his gun in order to enable it to carry the Armstrong shell, which for terrible destructiveness deserves to be almost more celebrated than the gun itself. Thus he states that as yet no fair comparison can be drawn between the results he has achieved while trying only for destructive effect, and the results obtained by a gun which was merely fired for range.

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The real test as to their merits both he and Mr. Whitworth very justly maintain can only be got by putting the two guns side by side, and trying them under similar conditions for range, accuracy, and above all for destructive effect. It has been suggested that there is room in the service for both the Armstrong and Whitworth guns, as each weapon has its peculiar attributes and its peculiar supporters. This, however, is taking a view of the case in which we think neither the public nor the War-office is at all likely to agree. Sir William Armstrong claims to have constructed his gun on certain fundamental principles; these Mr. Whitworth disregards, and forms his gun as unlike Sir William's in principle as two guns can well be. Now, both these ordnance cannot be right, and whichever comes out of the trials at Shœburyness triumphantly—whether it be the Whitworth or Sir William's—that is the gun to be eventually adopted in both services as soon as is consistent with the present immense demand for rifled ordnance of almost any kind.

Each gun, as we have said, is so essentially different in its principles, that, except that they are both guns, and both breech-loaders, there is no other point of similarity between them. The Armstrong is made of coils of wrought iron joined into one tube, the pitch of its rifling is one turn in 10 feet, and its rifling itself is 38 fine sharp grooves. The breech is formed by a long chamber fitting on to the end of the gun, *into* which works a powerful hollow screw, which, when screwed up, jams the breech-piece, which is dropped before it, into the end of the tube, and so makes the perfect gun. The conical shot is, of course, compound—that is, coated at the shoulder and base with rings of lead, to enable the soft metal to take the rifling. These rings of lead are expensive as compared with iron, and difficult to fix, and the shot must be driven through the hollow screw into the breech of the gun with care, or accidents would be likely to happen which might spoil the rifling of the gun. The friction on the shot in taking the rifling is enormous, and to this the recoil of

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the gun was at one time supposed to be due. But this was a mistake, for, allowing for the difference of weight between guns and projectiles, the recoil of all ordnance must be in mechanical proportion to the velocity with which the shot leaves the gun. That the friction on the shot, however, is very great may be judged from the fact that we have ourselves seen an Armstrong gun, from the muzzle of which not only the rifling, but the metal of the barrel itself had been stripped out in places like so much paper. The Armstrong shell, as a tremendous engine of warfare, is never likely to be surpassed in destructiveness, though, we should think, it can be be adapted to be used from rifled breech-loading cannon of all kinds. This however, remains to be seen. The Whitworth gun, as distinguished from the Armstrong is bored from one solid cylinder of homogeneous iron, a metal which, in our humble judgment, we take to be only another term for soft tough steel. There is no rifling as is generally understood by the term in the bore which is a plain hexagon, making one complete turn, which varies with the diameter of the gun. Thus there is one turn in about eight feet in the largest guns (from 50 to 120 pounders,) one complete turn in five feet in the medium sized ordnance (12 to 32 pounders,) and one complete turn in three feet four inches in the small guns, or from three to 12 pounders. All the guns above 18-pounders are hooped round with rings of iron forced on by hydraulic pressure—an additional strength which is apparently not required and which in weight gives the Armstrong guns of the same calibres a most important advantage. The breech-loading arrangement is a hinge at the end of the gun supporting a hoop of iron, in which is the breech or cap which screws on to the end of the piece. The shot is of cast iron, and in form precisely like a nine-pin, with its thickest part at the middle pared off to fit with mechanical precision the hexagonal sides of the bore. Thus the projectile has a bearing surface on the whole of the barrel, and runs freely in or out of the gun, so that in case of an enemy's shot striking

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the breech and jamming the screw, or other injury to it, the gun could be used as a muzzle-loader with the same facility as an ordinary smooth-bore field-piece. We need scarcely say that this is not the case with the Armstrong, anything happening to the arrangement of the breech at once rendering the gun useless till another breech is fitted on at the factories at Elswick or Woolwich. No exertion of force which could be applied to the gun in the field would get the shot down the barrel of the Armstrong; and nothing short of the pressure of several tons would suffice to overcome the friction which is offered by the double rings of lead to the exit of the shot at the muzzle. With the Whitworth gun there is no chamber for the reception of shot and powder, and no rings—an advantage of the utmost importance. The Armstrong chamber adds to the length of the gun, without being rifled or assisting in impelling the shot in any way. With the Whitworth the gun is rifled throughout its entire length from end to end, and every inch is used to aid the flight and give rotation to the projectile. From the chamber in the Armstrong being of a certain size, it follows that only shot of a certain length can be used. In the Whitworth, on the contrary, it is contended that shots of any length, or a charge of powder of any strength, can be used indifferently. Thus the three, 12, and 80 pounders are, in fact, only guns of the calibre we mention as long as they are required to throw a distance of 5 or 5½ miles. Reduce this enormous range to the distance at which long-range guns are generally used—say 3,000 yards—and the length of the projectiles of these ordnance may be more than doubled, the three-pounder used for 9lb. shot, the twelve-pounder for 32lb., and the eighty-pounder for a shot of even 200lb. In naval warfare great weight must be attached to these advantages. Twelve-pounder boat guns could be used as 12-pounders or 36-pounders, according to the distance at which they choose to engage, while ships could double-shot or even treble-shot their broad side guns as they closed with an enemy. The only limit, in fact, to the number

of shots with which the Whitworth can be loaded when engaged at close quarters is the limit to the strength of the powder to eject them. Thus, in the course of the experiments tried to ascertain this fact, it was found that the three-pounder got rid of 10 shots placed one over another at one discharge, but failed to eject 11, when all the powder in the charge burnt out like a squib through the touch-hole, leaving the shots in the gun. In the course of the same experiments Mr. Whitworth fired from a common howitzer a projectile 10 diameters long, and also fired a small cannon, 22 inches long, with the pitch of its rifling making one complete turn in every inch; in fact, the inside of this latter barrel was a perfect screw. Yet the projectile from this had an extraordinary amount of penetration. This fact is so difficult to believe till one sees the rapidity with which the hexagonal shot glides down the most rapid turn of rifling that one of our contemporaries has actually given credence to the monstrous *canard* that the Whitworth cast-iron shots have been crushed to fragments by the rifling, and "come forth from the gun *in a state of powder!*" As the Armstrong is now used without sponging out, Mr. Whitworth's advantage in this respect has been neutralised. As regards cost, the Armstrong is now being being manufactured for as low as £103 per gun. The cost of the Whitworth is at present quite double this amount, though it might be reduced to as low as or even slightly lower than the cost of the Armstrong if the barrel were manufactured of tubes of rolled bar iron, instead of the homogeneous metal, which is very expensive, and certainly for all practical purposes of gunnery is not stronger, we believe, than the wrought iron of Armstrong, or even stronger than the extraordinary wrought iron now making for guns at the Mersey Steel-works at £19 a ton. If in the trials of the two guns at Shoeburyness the Whitworth is found to be the best, and is ordered to be adopted, and its tube made on the wrought-iron plan which the Government use with the Armstrong, the only cost, it is stated, of altering

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the machinery at Elswick and Woolwich to suit the new manufacture would be some £5 or £10 or a new form of cutter for the boring, or rather the hexagonal rifling. Not another part of the machinery need be altered or even made to move faster or slower, though much of it might be disused altogether. Very many of the supporters of the Armstrong allege that it is useless adopting every improvement as it springs up, and that, after all the trouble of change has been taken, a better gun even than Whitworth's may be found before the year is out. This may be true. But if the War-office is to adopt this argument, and ignore the valuable inventions which they have got because there may be some other undiscovered ones of which they know nothing at all, what will become of the service; or when will a step in progress be ever made? Whichever gun is proved to be the best must owe its superiority to broad scientific principles, and any further improvement must therefore be merely a development of the same fundamental ideas, every step in which renders further progress less probable. If, however, there should be a dozen great improvements made in a dozen consecutive years, the public will never grudge the money for a change as long as they are convinced it is for the better. It is the gigantic sums which have been wasted on such rubbish as the Lancaster guns which make the House of Commons timid of the expediency of changes, or at least of those by whom they are carried out. To secure the perfect development of two such invaluable improvements as those of Armstrong and Whitworth undoubtedly are, the country would never flinch from any reasonable sum that might be required. Fortunately, however, whichever is selected, no further outlay, it is said, will be necessary in the way of plant or machinery; so we may await without any pecuniary misgiving the result of the forthcoming trials, and the official proclamation as to which gun is the best of the two. This result our readers may depend upon knowing as soon as it is definitively ascertained.—*Times.*

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The Ordnance Select Committee.

25th September 1857.

No. 1209.

Subject:

Captain CAFFIN, R. N.,—ROPE MANTLETS,

With reference to Report, dated 18th September 1856, No, 925.

Remarks by the Committee.

The Committee have carried on a series of experiments with rope mantlets constructed by the Russians for the defence of Sebastopol, and with others made in the same manner as those prepared on board the British Fleet for the attack of that fortress; they have also consulted the records of former experiments carried on at the Royal Engineer Field Establishment, Chatham.

From the result of the experience thus gained, they have had a rope mantlet constructed which is proof against the Enfield rifle bullet at 50 yards.

This mantlet consists of five layers of rope, 4½ inches in circumference, the two central layers lying parallel to each other, and the layers next to them lying across the former. The thickness of this mass of rope is very great, about 7 inches, and it is very heavy, weighing 27½ lbs. per square foot. Supposing, therefore, that one were constructed so as to cover merely the *lower* half of the opening of an embrasure, it would weigh 165 lbs.

The Committee have prepared the accompanying table to show the thickness of mantlet required to resist the Enfield rifle bullet at different distances, from which it will be seen that one formed of two thicknesses of 7-inch rope, which weighs 21 lbs. per square foot, is proof, at 200 yards, and this being lighter, may be found in some cases more useful

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than the one before mentioned; it may be remarked that if two of them were hung up together, they would be proof at 50 yards.

It does not appear to the Committee to be advisable to introduce any special description of mantlet into the service for general purposes.

When the use of mantlets is requisite, much will depend in their construction, on the particular nature of the service for which they are required, and the means of manufacture at disposal; but it seems desirable that the experience gained by these experiments should be made known to the two services.

Description, Weight, &c. of Rope Mantlets, showing at what distance they afford protection from the Enfield Rifle Bullet.

Distinguishing Number.	Description &c.			Dimensions superficial feet.	Weight.				Remarks.
	Rope laid.		Construction.		Total.			per foot superficial.	
	Layers	Size.	Layers.						
	No.	Inches			cwt.	qrs.	lbs.	lbs.	
1	5	4½	2 Vertical. 2 Horizontal. 1 Vertical.	16	3	3	21	27½	Affords protection at 50 yds.
2	3	5	Vertical.	34	6	0	13	20	Affords protection at 100 yds.
3	2	6	,,	30	4	2	24	17	Affords protection at 200 yards, but not under. No. 3, not always at that distance; two of No. 4, hung together, afford protection at 50 yards.
4	2	7	,,	28	5	1	4	21	

W. Cator D. G.

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23rd October 1857

No. 1241.

Subject :

Captain Caffin. C. B., R. N.,—Rope Mantlets.

With reference to Report of the Committee 25th September 1857, and to letter dated W. O., 22-10-57, $\frac{84}{\frac{c}{37}}$

Remarks by the Committee.

The Committee beg leave to forward the Photographs of the different kinds of Rope Mantlets, and the details of Experiments called for by the Secretary of State for War.

(Signed) W. Cator, D. G.

Result of Experiments carried on between the 12th and 18th November 1856, to ascertain the amount of protection afforded by some Russian Rope Mantlets against the Enfield Rifle Service Ammunition.

Weight of ball, 530 grs. ; charge. 2½ drs., F. G.

Description of Mantlet.

Distinguishing Number.	Description &c.						Dimensions superficial feet.	Weight.				Remarks.
	Rope laid.		Yarn loosely laid up, plaited three strand as Gasket.		Construction			Total.			per superficial foot.	
	Layers.	Size.	Layers.	Size.	Layers.	Plat as Gasket.						
	No.	Ins	No	Ins.				cwts.	qrs.	lbs.	lb.	
1	3	4	......	......	Vertical.	....	29	4	1	26	17	
2	2	4½	......	......	”	....	21	2	2	20	14	
3	3	5	......	......	”	....	32	4	2	14	16	
4	3	5	......	......	”	....	34	6	0	13	20	
5	2	6	......	......	”	....	30	4	2	24	17	
6	2	7	......	......	”	....	28	5	1	4	21	
7	1	3	1	5	Horizontal.	Vertical.	15	2	1	2	16	(Plat on flat.)
8	1	2½	1	5	”	”	16	2	1	10	16	” ”
9	...	...	2	5	”	”	16	2	1	24	17	(Plat on edge.)
10	...	...	6	4½	2	4*	14	3	0	20	25	* (2 inside and 2 outside.)

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Owing to obstructions the longest range which could be had was 300 yards. The mantlets were hung up, and a 2-inch deal target placed 3½ feet behind them.

No. 1 Mantlet.

At a range of 200 *yards.*

No. 1 shot, sent through mantlet, and 1 in. into target. } Struck between strands.
2 „ sent through mantlet, and indented target. } Struck between strands.
3 „ remained in mantlet, 2 in. deep, struck on brace.
4 „ through mantlet, indented target, between strands.
5 „ remained in mantlet, 2½ in. deep, on strand.

At a range of 300 *yards.*

No. 1 shot, remained in mantlet, 1½ in. deep, struck on strand.
2 „ through mantlet, indented target ¼ in., between strands.
3 „ through mantlet, into target ¼ in., between strands.
4 „ remained in mantlet, 2½ in. deep, on strand.

Not a sufficient protection up to or at 300 yards.

No. 2 Mantlet.

At a range of 200 *yards.*

No. 1 shot, through mantlet, indented target, struck on strand.
2 „ through mantlet and target do. do.

At a range of 300 *yards.*

No. 1 shot, remained in mantlet, 1 in. deep, on strand.
2 „ do. do. do.
3 „ do. do. do.
4 „ do. do. do.
5 „ through mantlet into target, 1 inch, between strands.

Not sufficient protection at 300 yards.

No. 3 Mantlet.

At a range of 100 *yards.*

No. 1 shot, through mantlet, entered target 1 inch, on strand.

At a range of 300 *yards.*

No. 1 shot, through mantlet, entered target sideways } between strands.
2 „ through mantlet into target, 1 inch. } between strands.
3 „ through mantlet, indented target only on strand.

Not sufficient protection at 300 yards.

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No. 4 Mantlet.

At a range of 100 *yards.*

No. 1 shot, remained in mantlet 2¼ inch deep, struck on strand.
2 „ ditto ditto
3 „ ditto ditto
4 „ ditto ditto
5 „ ditto 3 inch deep, between strand
6 „ ditto 1½ inch deep, on strand.
7 „ through mantlet, marked target, but did not enter between strand.
8 „ remained in mantlet 1½ inch deep on strand.
9 „ ditto ditto
10 „ ditto ditto
11 „ ditto ditto
12 „ ditto nearly through, between strand.
13 „ ditto 2 inch deep, ditto.
14 „ ditto 1½ inch deep, on strand.
15 „ ditto 2½ inch deep, between strand.

At a range of 50 *yards.*

No. 1 shot, through mantlet, 1 inch into target, between strand.
2 „ ditto struck, but did not enter target.
3 „ nearly through mantlet, head of bullet showing.

At a range of 20 *yards.*

No. 1 shot, through mantlet, into the target 1 inch.
2 „ ditto struck, but did not enter target.
3 „ ditto into target 1 inch.

Would appear to be a protection at 100 yards, but not under.

No. 5 Mantlet.

At a range of 100 *yards.*

No. 1 shot, through mantlet, into target 1 inch, between strands.
2 „ remained in mantlet, 3 inch deep, struck on strands.
3 „ ditto ditto ditto.
4 „ remained in mantlet, on strand.
5 „ ditto ditto.
6 „ ditto ditto.
7 „ through mantlet, struck but did not enter target between strands.
8 „ remained in mantlet, struck between strands.
9 „ through mantlet and target, between strands.
10 „ ditto into ditto ditto.

No. 5 Mantlet.

At a range of 200 yards.

No. 1	shot,	remained in mantlet half way through,	between strands.
2	"	ditto	ditto.
3	"	ditto	ditto.
4	"	ditto	ditto.
5	"	ditto	ditto.
6	"	ditto	ditto.
7	"	remained in mantlet, but nearly through, showing head of bullet at back, between strand.	

A good protection at 200 yards, but not a thorough one; not sufficient protection at 100 yards.

No. 6 Mantlet.

At a range of 100 yards.

No. 1	shot,	remained in mantlet,	on strand ¾ inch deep.
2	"	ditto	2 inch deep, on strand.
3	"	ditto	2½ inch ditto.
4	"	ditto	1½ inch ditto.
5	"	remained in mantlet, nearly through, between strand.	
6	"	through mantlet, marked, but did not enter target, between strand.	
7	"	remained in mantlet, ¾ inch deep, on strand.	
8	"	through mantlet, into target 1 inch, between strand.	
9	"	remained in mantlet 1½ inch deep,	ditto.
10	"	ditto	1 inch deep, on strand,

At a range of 200 yards.

No. 1	shot,	remained in mantlet,	between strand.
2	"	ditto	2¼ inch, on strand.
3	"	ditto	4 inch, between strand.
4	"	ditto	¾ inch, on strand.
5	"	ditto	ditto.
6	"	ditto	2 inch deep, on strand.
7	"	ditto	1½ inch, between strand.
8	"	ditto	1½ inch, on strand.
9	"	ditto	1 inch deep, on strand.
10	"	ditto	2½ inch deep, between strand.

Would appear to afford protection at 200 yards, but not at 100 yards.

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No. 7 Mantlet.

At a range of 100 yards.

No. 1 shot, through mantlet into target 1 inch.
2 ,, ditto ditto.
3 ,, ditto and target.
4 ,, ditto ditto.
— between and on strands.

At a range of 200 yards.

No. 1 shot, through mantlet and target.
2 ,, ditto ditto.
— between and on strands.

At a range of 300 yards.

No. 1 shot, through mantlet and target.

No protection at 300 yards.

No. 8 Mantlet.

At a range of 200 yards.

No. 1 shot through mantlet and target, placed No. 9 mantlet 3 feet behind No. 8.
No. 1 shot through 8 into 9, 1½ inch.
2 ,, ditto 1 inch.
3 ,, through 8 and nearly through 9.
— between and on strands.

At a range of 300 yards.

No. 1 shot, through mantlet into target ¾ inch.
2 ,, ditto ditto ½ inch.

No protection at 300 yards.

No. 9 Mantlet.

At a range of 200 yards.

No. 1 shot through mantlet and target, between strands.
2 ,, through mantlet, struck target but did not enter between strands.
3 ,, through mantlet and target, on strands.

At a range of 300 yards.

No. 1 shot, through mantlet into target 1 inch.
2 ,, ditto and target, between strands.
3 ,, through mantlet, struck target, but did not enter between strands.

No protection at 300 yards.

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No. 10 Mantlet.

At a range of 300 *yards.*

No. 1 shot, through mantlet and target.
2 „ ditto ditto.
3 „ ditto ditto.

No protection at 300 yards.

From the above experiments it would appear that Nos. 4, 5, 6 mantlets are the only ones which afford protection at close quarters, neither of them under 100 yards range, No. 4 being the best, and affording protection at 100 yards; Nos. 5 and 6 affording protection at 200 yards, but not under; No. 5 not always at that distance; Nos. 1, 2, 3, 7, 8, 9, 10, no protection at 300 yards.

(Signed) ALEX. T. TULLOH. Col. R. A.,
Supt. R. C. D.

(Signed) G. FRASER, Captain R. A.,
Capt. Inspector R. L.

Royal Carriage Department.
10th March 1857.

MEMORANDUM of ROPE MANTLETS made for Select Committee.

Distinguishing Number.	Description &c.				Dimensions feet superficial.	Weight.				Remarks.
	Rope laid.		Construction.			Total.			Per foot superficial.	
	Layers.	Size.	Layers.	—						
	No.	Inches.			feet	cwt.	qrs.	lbs.	lbs.	
1	4	4½	{ 2 2	vertical horizontal	} 16	3	1	0	22¾	{ 2 inside on vertical. 2 outside horizontal.
2	4	4½	4	vertical	16	3	0	13	21¾	—

(Signed) A. T. TULLOH, Col. R. A.
Supt. Royal Carriage Dept.

Royal Arsenal 7th May 1857.

RESULTS of EXPERIMENTS carried on 6th May 1857, to ascertain the protection afforded by four different Mantlets

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against the Enfield Rifle Service Ammunition, and the 1842 pattern Rifle Service Ammunition, at different ranges.

5 in. thick plats, vertical and horizontal, of ropes, 4½ in.; two of each size; 4 feet square; weight, 3 cwt. 1 qr.

The first mantlet tried was a rope one; description in the margin; at a range of 50 yards, with the Enfield Rifle.

No. 1 shot, remained in mantlet 2½ in. deep, struck between ropes.
2 „ ditto 2¾ in., struck on rope.
3 „ ditto 4½ in. ditto
4 „ went through mantlet, into wood target behind, of deal, and penetrated its own depth, struck between ropes.
5 „ remained in mantlet 4½ in., struck on rope.
6 „ ditto 4½ in. ditto
7 „ ditto 2¾ in. between ropes.
8 „ ditto 3 in. on rope.
9 „ went through mantlet, indented target.
10 „ ditto ditto. struck between ropes.

The 1842 pattern rifle was next used against the mantlet, at the same range.

No 1 shot, remained in mantlet 3½ in., struck on rope.
2 „ ditto 4½ in., struck between rope.
3 „ ditto 4½ in., struck on rope.
4 „ ditto 4½ in. ditto.
5 „ ditto 4¾ in. ditto.

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5 in. thick plats, vertical, rope 1½ in., 4 plats; size, 3 feet 8 in. by 4 feet; weight, 3 cwt. 12 lbs.

The next mantlet fired at was of rope; the Enfield Rifle being used at a range of 50 yards.

No. 1 shot went through mantlet, did not indent target at back, struck on rope.
2 „ went through mantlet, did not indent target at back, struck between ropes.
3 „ went through mantlet and target between ropes.

The 1842 pattern rifle was next used, against the same mantlet at the same range.

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No. 1 shot, through mantlet, indented target, between ropes.

Steel plates $\frac{1}{16}$ in. thick, laid horizontal, so as to slightly overlap, backed by hide; size 2 ft. 6 in. by 2 ft. 2 ins; weight, 1 qr. 2 lbs., being about $5\frac{1}{2}$ lbs. to the superficial foot.

The next mantlet tried was of steel, backed by hide; the Enfield rifle being used at a Range of 200 yards.

No. 1 shot, indented, but did not penetrate or crack the plate.
2 „ ditto ditto ditto ditto

Moved up to 150 yards.

No. 1 shot, went through mantlet.
2 „ did not penetrate, but indented deeply, and cracked the mantlet.
3 „ went through mantlet.

Steel plates $\frac{3}{8}$ in. thick, laid horizontal, so as to slightly overlap; size 2 ft. 6 ins. by 2 ft. 8 in.; weight 1 cwt. 21 lbs. being about 20 lbs. to the superficial foot.

The next mantlet tried was of steel, backed with hide, thicker than the last; the Enfield Rifle being used at a range of 150 yards.

No. 1 shot made no impression on the mantlet.

Moved up to 50 yards range.

No. 1 shot made no impression on the mantlet.

Moved up to 25 yards range.

No. 1 shot made not the least impression on the mantlet.

Enfield Rifle.
Weight of bullet...530 grs.
Charge .... $2\frac{1}{2}$ drs.

Musket Rifled Pattern 1842.
Weight of bullet...848 grs.
Charge .... 3 drs.

(Signed) G. Fraser, Captain R. A.

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Table of Charges for Ordnance and Bursting Charges for Shells.

AUTHORIZED BY THE SECRETARY OF STATE FOR WAR, 1859.

Ordnance.				Charges.					Bursting charges for Shells.				
Nature.	Length.		Weight.	Proof.	Shot, or Diaphragm-Shrapnel Shells.	Improved Shrapnel Shells.	Common Shells.	Saluting or Exercising.	Diaphragm-Shrapnel.	Improved Shrapnel.		Common.	
Iron Guns.	ft.	ins.	cwt	lbs.	lbs.	lbs.	lbs.	lbs.	drs.	oz.	drs.	lbs.	oz.
10 Inch	9	4	86	20	hollow shot *12	There are no 10 inch improved Shrapnel	12	6	not used	not used		5	0
8 Inch ...	9	0	65	20	hollow shot 10	8	10	5					
ditto	8	10	60	18	hollow shot 10	8	10	5					
ditto ...	8	0	52	16	hollow shot 8	6	8	5	60	4	3	2	4
ditto	6	8½	50	14	hollow shot 8	6	8	5					
68 Pdr. ...	10	10	112	30	18	10	10	8					
ditto	10	0	95	28	16	10	10	8					
ditto ...	9	6	88	25	14	10	10	8					
56 Pdr.	11	0	98	28	14	10	10	8	55	4	2	2	0
ditto ...	10	0	87	25	14	10	10	8					
42 Pdr.	10	0	84	25	14	10	10	8					
ditto ...	10	0	75	25	12	10	10	8	50	2	12	1	6
ditto	9	6	67	23	10½	10	10	8					
32 Pdr. ...	9	7	63	21½	10	10	10	6					
ditto	9	6	58	21½	10	10	10	6					
ditto ...	9	6	56	21½	10	10	10	6					
ditto	8	0	48	21½	8	8	8	5					
ditto ...	9	0	50	18	8	8	8	5					
ditto	8	6	45	16	7	7	7	5					
ditto ...	8	0	42	14	6	6	6	4					
ditto	9	0	46	12	6	6	6	4	40	2	8	1	2
ditto ...	8	0	41	12	6	6	6	4					
ditto	7	6	40	12	6	6	6	4					
ditto ...	7	6	39	12	6	6	6	4					
ditto	6	6	32	10	5	5	5	3					
ditto ...	6	0	25	9	4	4	4	2½					
ditto	5	4·1	25	9	4	4	4	2½					

* There are no Diaphragm-Shells for 10 inch guns.

† When firing Naval Common Shells, 16 lbs. charges to be used with 68-Pdr. Guns of 112 and 95 cwt.

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(*CONTINUED.*)

Ordnance.				Charges.					Bursting charges of Shells.		
Nature.	Length.		Weight.	Proof.	Shot, or Diaphragm-Shrapnel Shells.	Improved Shrapnel Shells.	Common Shells.	Saluting or Exercising.	Diaphragm-Shrapnel.	Improved Shrapnel.	Common.
Iron Guns.	ft.	ins.	cwt	lbs.	lbs.	lbs.	lbs.	lbs.	drs.	oz. drs.	lbs. [illegible]
24 Pdr.	9	6	50	18	8	8	8	5			
ditto ...	9	0	48	18	8	8	8	5			
ditto	7	6	41	15	6	6	6	4	30	1 9¼	0 [illegible]
ditto ...	6	6	33	12	4	4	4	3			
ditto	6	0	20	6	2½	2½	2½	2½			
18 Pdr. ...	9	0	42	15	6	6	6	4			
ditto	8	0	38	15	6	6	6	4			
ditto ...	7	0	22	7	3	3	3	3	25	1 8	0 [illegible]
ditto	6	0	20	7	3	3	3	3			
ditto ...	5	6	15	5	2	2	2	2			
12 Pdr.	9	0	34	12	4	4	4	3			
ditto ...	8	6	33	12	4	4	4	3			
ditto	7	6	29½	12	4	4	4	3	20	1 0½	0 [illegible]
ditto ...	6	0	21	10	4	4	4	2½			
9 Pdr.	8	6	28½	9	3	3	not used with this Gun.	2			
ditto ...	7	6	26	9	3	3	ditto	2	15	0 14	not used with [illegible]
ditto	7	0	25	9	3	3	ditto	2			
ditto ...	5	6	17	8	3	3	ditto	2			
6 Pdr.	7	6	21	6	2	2	ditto	1½			
ditto ...	7	0	20	6	2	2	ditto	1½	10	0 9½	
ditto	6	0	17	6	2	2	ditto	1½			
Brass Guns.											
12 Pdr.	6	6·6	18	5	4	4	4	3	20	1 0½	0 [illegible]
9 Pdr. ...	6	0	13½	3¼	2½	2½	not used with this Gun.	1¼	15	0 14	not used with [illegible]
6 Pdr.	5	0	6	2	1½	1½	ditto	1	10	0 9½	
3 Pdr. ...	4	0	3	1	12oz	not used with this Gun.	ditto	12 ozs.			
ditto	3	0	2½	1	10 oz.	ditto	ditto	10 ozs.	not used	not used	
1 Pdr. ...	5	0	2½	½	6 oz.	ditto	ditto	6 ozs.			
Iron Howitzers.											
10 Inch	5	0	41	12	not used	not used	7	4	not used	not used	[illegible]
8 Inch ...	4	0	21	8	3	3	4	3	60	4 3	[illegible]
5½ In., or 24 Pdr.	3	4·76	15	6	2	2	2	2	30	1 9¼	0 [illegible]

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(CONTINUED.)

Ordnance.			Charges.					Bursting charges for Shells.		
Nature.	Length.	Weight.	Proof.	Shot, or Diaphragm-Shrapnel Shells.	Improved Shrapnel Shells.	Common Shells.	Saluting or Exercising.	Diaphragm-Shrapnel.	Improved Shrapnel.	Common.
rass Howitzers.	ft. ins.	cwt	lbs.	lbs.	lbs.	lbs.	lbs.	drs.	oz. drs.	lbs. oz.
32 Pdr.	5 3	17½	4	3	3	3	2	40	2 8	1 2
24 ditto ...	4 8·6	13	2½	2½	2½	2½	1½	30	1 9½	0 13
12 ditto	3 9·2	6½	1¼	1¼	1¼	1¼	1	20	1 0½	0 6
4⅖ In., or Cohorn.	1 10·6	2½	1	not used	not used	8 ozs.	4 ozs.	not used	not used	0 6
Iron Mortars.	Inches.	cwt	lbs. oz.	lbs. oz.		lbs. oz.				Mortar
13 In. S. Service.	52·8125	100	20 11	not used	not used	20 0		not used	not used	10 8
13 In. L. Service.	39·65	36	9 0	ditto	ditto	9 0				
10 In. S. ditto	45·62	52	9 8	ditto	ditto	9 8		ditto	ditto	5 0
10 In. L. ditto	31·53	18	4 0	ditto	ditto	4 0				
8 In.	25·23	9	2 0	ditto	ditto	2 0		ditto	ditto	2 4
Brass Mortars.										
5½ In., or Royal.	15·1	1¼	0 7	ditto	ditto	0 7		ditto	ditto	0 13
4⅖ In., or Cohorn.	12·7125	¾	0 5	ditto	ditto	0 5		ditto	ditto	0 6
on Carronades.	ft. ins.		lbs							
68 Pdr.	5 4	36½	13	5 0	ditto	not used	5 0	ditto	ditto	not used
42 Pdr. ...	4 6	22	9	3 8	ditto	ditto	3 8	ditto	ditto	ditto
32 Pdr.	4 0	17	8	2 11	ditto	ditto	2 11	ditto	ditto	ditto
24 Pdr. ...	3 9	13	6	2 0	ditto	ditto	2 0	ditto	ditto	ditto
18 Pdr.	3 4	10	4	1 8	ditto	ditto	1 8	ditto	ditto	ditto
12 Pdr. ...	2 8	6	3	1 0	ditto	ditto	1 0	ditto	ditto	ditto
6 Pdr.	2 9	4¾	1½	0 10	ditto	ditto	0 10	ditto	ditto	ditto
										Common
Naval Shells.	....	...	......	......	......	......	...	10 inch	......	6 4
								8 „	......	2 4
								32 Pdr.	......	1 0
land Grenades.	....	...	......	......	......	......	...	Sea Service.		0 4
								Land Service.		0 2

. B. The Bursting Charges for Diaphragm-Shrapnel, and improved Shrapnel Shells, are composed of medium e Powder, those for all other shells of large grain Powder.

The ordinary Common Shells are used with these Mortars.

Approved by Secretary of State for War.

19th November 1859 $\frac{55}{\text{Artillery}}{\frac{}{1016}}$, and 23rd November 1859 $\frac{75}{7}{\frac{}{128}}$

J. St. George Colonel,
President Ordnance Select Committee

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Royal Artillery.

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HORSE GUARDS S. W.
24th January 1860.

GENERAL REGIMENTAL ORDER.

With reference to the General Regimental Order, No. 407, of the 12th August last, in which the proportions of Shell and Fuze Implements for Fortresses and permanent Batteries were promulgated. The General Commanding-in-Chief desires the following list of similar Implements for Field Artillery Service, which have, at the recommendation of the Ordnance Select Committee, and with the concurrence of His Royal Highness, been approved by the Secretary of State for War, to be communicated for the information and guidance of the Regiment.

No. 1 *Set. For each Gun or Howitzer.*

Borers. Hand, in Canvas bag	1	For preparing Fuzes.
Borers. Hook, in Canvas bags	2	
Cylinders, Wood, in Canvas bags, each containing 6 long and 6 short bits	2	
Extractor, Fuze	1	
Mallet	1	
Setter	1	
with		
Instructions, printed	5	
Sections of Fuzes	5	

No. 2 *Set. For each Gun.*

Drift, Wood, for 18 to 6-pounder Diaphragm-Shrapnel Shell	1	For loading, securing, and preparing Shells.
Funnel, for 18 to 6-pounder Diaphragm-Shrapnel Shell	1	
Keys, Iron, for Fuze-hole Plug	2	
Punch for rivetting bottoms, (to be carried in "near" axletree box)	1	
Screw-drivers for 18 to 6-pounder Diaphragm-Shrapnel Shell loading-hole	1	
with		
Instructions, printed	2	

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No. 3 Set. For each 32 or 24-pounder Howitzer.

For loading, securing, and preparing Shells.

Drifts, wood, for	Common Shell...	1
	32 or 24-pounder Diaphragm-Shrapnel Shell ...	1
Funnels for	Common Shell...	1
	32 or 24-pounder Diaphragm-Shrapnel Shell ...	1
Keys, Iron, for Fuze-hole Plug		2
Punch for rivetting bottoms (to be carried in "near" axletree box)		1
Screw-drivers for 32 or 24-pounder Diaphragm-Shrapnel Shell loading-hole		1
with		
Instructions, printed		2

No. 4 Set. For each 12-pounder Howitzer.

For loading, securing, and preparing Shells.

Drifts, wood for	Common Shell...	1
	18 to 6-pounder Diaphragm-Shrapnel Shell ...	1
Funnels for	Common Shell...	1
	18 to 6-pounder Diaphragm-Shrapnel Shell ...	1
Keys, Iron, for Fuze-hole Plug		2
Punch for rivetting bottoms (to be carried in "near" axletree box)		1
Screw-drivers for 18 to 6-pounder Diaphragm-Shrapnel Shell loading-hole		1
with		
Instructions, printed		2

These Implements being nearly identical with those now in use, the exchange of the latter will take place only as they become unserviceable.

The Secretary of State for War having, at the recommendation of the Ordnance Select Committee, and with the concurrence of the General Commanding-in-Chief, approved of the following arrangements, they are published for the information and guidance of Commanding Officers of Artillery; and in consequence thereof, Paragraph 7 of General Regimental Order, of 2nd September, 1859, No. 409, is cancelled.

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Metal Plugs will be screwed into all Shells fixed to wood bottoms prior to issue; and if the Shells be issued loaded, the word " Loaded" will be painted on the Shell Box.

All Common Shells, whether fixed to wood bottoms or loose, either for Field Artillery or Garrison Service, will be issued with the Metal Plug screwed into the Fuze-hole.

For Common Shells, issued loose, the proportion of spare plugs, bottoms, rivets, &c. is to be—

Bottoms........................	10	per Cent.
Rivets........................	10	,,
Wads........................	5	,,
Plugs........................	10	,,

For Common Shells, issued with bottoms fixed, 5 per Cent. each of spare wads and plugs for Garrison Service, and 10 per Cent. for Field Service.

Diaphragm-Shrapnel Shells will always be issued with wood bottoms fixed; and the proportion of spare wads and plugs (fuze-hole and loading-hole) is to be, 5 per Cent. for Garrison Service, and 10 per Cent. for Field Service.

Spare bottoms, plugs, rivets, and wads, will be issued on demand only, and Commanding Officers of Artillery will be held responsible that the proper proportions of spare articles are kept on charge.

Boxes, to contain spare plugs, &c., for Shells, have been adopted into the Service, and will be supplied to Batteries of Field Artillery in the proportion of one per 24-pounder Howitzer, and 9 and 6-pounder Guns; and 2 per 12-pounder Howitzer; to be carried in the off limber boxes of the Carriages.

In requisitions for Fuze and Shell Implements, every article is to be detailed separately, and the "Set" to which it belongs specified.

By Command of

HIS ROYAL HIGHNESS THE DUKE OF CAMBRIDGE;

CHAS. BINGHAM,

Deputy Adjutant General.

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On the construction of Wheels and the form of Axles.

The following extract from a paper read at a Meeting of the SOCIETY OF ARTS* on the construction of Wheels and the form of Axles, will doubtless be read with much interest, as the established plan for constructing the highly efficient wheel of the Madras Artillery, coincides in a remarkable degree with much that is advocated by the author of this paper.

"The SECRETARY stated that he had received the following communication from Mr. W. Bridges Adams :—

"The machinery at Woolwich Arsenal for the manufacture of wheels for gun and other carriages, is fast approaching perfection, but the wheels themselves are still the rude primitive constructions, as regards principle, that Thespis might have used in his original cart. A lump or hub of timber is cut from the butt of a tree. A series of levers are fixed round it, capstan bar fashion, but without the proportioned strength of the capstan bars, each of which is equally strong all over, whereas each spoke is so reduced at the tenon, or holding part, where it enters the hub, that it would break short off if unsupported. The extreme ends of the levers are framed into the fellies, or string segments, two and two, in such wise that the spokes must be made weak in the direction of the plane of the wheel, in order to draw them together, to enable the extremities to enter the mortices. The fellies, where they abut against each other, are dowelled into short cross grain, produced by the curved form, and constantly break off at what are technically called the "chins," and loose segments of iron bar, technically called "strakes," are spiked on to the felly "break joint."

* January 1857.

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" Such wheels as these are now only to be found in remote districts, and the only apparent reason why they are continued in government artillery, is some fancied facility of repairs when damaged in use in the field.

" These wheels are so applied to the axletrees, that the lower spoke presses vertically on the ground, in order to prevent side rack and strain. But the result of this is a total absence of elastic resilience. As the wheel revolves with its load, blows from the irregular surface of the ground, act like tilt hammers, and drive the spokes partly into the hub, and partly into the fellies, but most into the hub because it is the softest wood, rendering the whole loose. But there is a worse evil than this. No hub is equally hard all round—the weather side of the tree is the toughest—consequently the spokes drive unequally, the wheel becomes eccentric, and the irregular action is like that of a sledge hammer, rapidly destroying it.

" When this class of wheel is improved, as in the ordinary omnibus, by shrinking on a hoop tyre, there is another difficulty. The spokes are thinnest in the direction of the plane of the wheel, and if the shrinking be too severe, they lose their straightness, and tend to lap round the hub, weakening the structure. As the hubs are not of equal hardness, scarcely any two wheels are alike in dish or diameter. If the spokes do not yield in the direction of the plane of the wheel, but are forced over in the direction of the axle or " dish" the tendency is to draw them forward, and leave gaps in the hub behind. When the diameter of the wheel is thus lessened, the tyre gets loose, and is then " cut and shut," to reduce it in diameter, and the gaps at the backs of the spokes are increased.

" Criticism is of little use, unless the critic has a remedy to offer. My remedy is first to dispense with the hub altogether, and mitre the spokes together at the centre in an

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arch form, bolting them between strong wrought iron disc plates front and back. The section of the spokes is such as to leave twice the strength in the direction of the plane of the wheel, to that in the direction of the axle. Each spoke has a single felly, the joints being between; the fellies being short there is no cross grain to break off the "chins." No dowels are applied, but instead of these a thin piece of narrow hoop iron is inserted in a saw kerf, half in each felly, which keeps them in plane, while the tyre is shrunk on. No shrinking of the tyre can damage the wheel, for the elastic resilience is in the direction from back to front, tending to produce a ribbed dome-shape, the true form of a wheel.

"I had come to the conclusion from theory that every spoke ought to have its separate felly, just as every leg has its separate foot, independently of the obvious disadvantage of straining the spokes to get them into the double felly. But I also obtained practical evidence of it.

"Watching on one occasion the pulling to pieces of a pair of large Hansom cab wheels, the fellies of which were made of hard wood, I found almost every double felly had separated into two parts, equi-distant between the spokes, forming, in fact, single fellies, and the separations were as clear and peculiar as the sutures in a skull bone, scarcely showing on the external paint. The reason was obvious. The wheels being of larger diameter, and revolving rapidly, the alternate blows at the ends and centres of the fellies concentrated the vibrations at the centre, precisely in the mode in which axletrees break after long service. Each spoke served as a fulcrum to produce this effect. It was therefore clear that the structure which the wheel tended to generate in action, was the true structure to begin with, unless the fellies could be made in an entire solid piece.

"I tried this experiment also, constructing the wheel centres of mitred spokes, disc plated, and the fellies of a hoop

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of angle iron, into which the spokes abutted, and were very carelessly secured by staples round them, riveted into the angle iron. The wheels so made were placed under a cart, to carry heavy loads of iron. After being a considerable time in use, one day the angle circle escaped from one of the wheels. The driver lifted it into his cart with the rest of the load, and drove home on the spoke ends, which, when he arrived, bore the appearance of overworn crutches. The remark of one of the initiated in wheels on beholding this was, "No wheel that ever I saw before could do that"*

"It is obvious that a true circular form can be preserved by this kind of centre, but there is another advantage. The wheel, being dome-form, will be elastic, and if the axle be horizontal, the spokes will never be vertical to the ground. Consequently the result will be a spring action, diminishing draught and injury to the horses, while ensuring far greater durability. It will be as though a man alights upon his toes instead of his heels in jumping from a height.

"I frequently conversed with the late Colonel Colquhoun of the Woolwich Arsenal, on this subject, and he agreed with me in the principles, but the application involved such a radical change, and a new teaching in all departments connected with the working and repair of wheels, that he considered it preferable to go on in "the old way."

"It is, however, a most important matter, and the facility of repairs in the field would appear to be quite as great as with the primitive wheel. By means of an efficient screw tool, this wheel could be compressed into the cold hoop tyre in the open field very rapidly, and the parts being all duplicates, no error could occur. I think common labourers would be adequate to the work after a few weeks' practice.

* The disc centre alluded to was not originally an invention of mine. It was first used by Mr. Walter Hancock in his steam carriage, but not as a dished wheel—only as a cylindrical wheel—If I mistake not there is a model of a disc mitred centre wheel in Woolwich Arsenal.

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On the adaptation of metals to the construction of Artillery.

A very interesting discussion on the adaptation of metals to the construction of artillery, has been carried on at several successive weekly meetings of the Institution of Civil Engineers.* It could not fail to lead to the consideration of the systems of form and manufacture applied by different eminent inventors in their several propositions for the new rifled cannon.

Both Sir William Armstrong and Mr. Whitworth, the two great rivals now in the field, produced at different meetings a full-sized 12-pounder of their respective constructions, and each fully explained the good properties in them to which they laid claim.

The following points, however, suggested themselves to us during the discussion as being worthy of further explanation.

The very basis of the subject under discussion, namely, the nature of the force arising from the explosion of gunpowder, did not seem to be quite understood.

The reasonings on it were founded upon a fallacy, as regards artillery, in considering that the gun has only to resist the pressure of the volume of gas into which the solid substance of the gunpowder is expanded, laid down with much precision at so many pounds per square inch; whereas, by the rapidity of the action, there is a violent blow, as it were, to be provided for in addition. The force of this blow will hardly admit of calculation, but adds greatly to the pressure.

An illustration of this effect may perhaps be given in certain trials on the power of a spiral spring for buffers for railway carriages; these springs were found to possess great tenacity in drawing or resisting the gradual pressure of

* Amongst the engineers and others who took part in the discussion were Mr. Bidder, the President, Sir W. Armstrong, Mr. Whitworth, Sir John Burgoyne, Colonel Eardley Wilmot. Captain Boxer, Mr. Abel, Captain Moorsom, Mr. Longridge, Sir Charles Fox, Captain Blakeley, Mr. Anderson, Mr. Lancaster, Mr. Bashleigh Britten, Mr. Hadden, and others,

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enormous loads, but when there was a desire to show that they might act beneficially in some cases of collision, and a locomotive was run upon a train of carriages at rest, although at a rate of only two or three miles an hour, they broke at once at the impulse.

Such is the shock, then, which the gun has to sustain, in addition to the pressure caused by the expansion.

There is another force also brought to bear on the gun, which has not entered into the calculations, and that is the great heat which is suddenly generated.

The very rapid expansion of the inflamed gas has a great tendency to disintegrate any fibrous material, and penetrates into the most minute interstices of the metal, and if it finds an outlet to the air through a small passage, it acts like a blowpipe. In this way the vents of the cast-iron heavy guns at the sieges in the Peninsula, after quick firing of hundreds of rounds, were enlarged from the size of a small quill to rugged openings that would admit two or three fingers.

It was these effects that have caused disappointment to many of the older inventors of guns, who had only taken the simple pressure into calculation.

The next matter on which discussion arose was the best material and principle of manufacture.

Here we have the old cast-iron and the brass, hoops applied hot or cold, twisted bars, envelope of coils of wire, the homogeneous metal, steel. &c.

Some gentlemen have declared that they have not lost all faith in cast-iron; but, as we think, with little reason.

The very great weight that must necessarily be given to cast iron guns is a most serious disadvantage ; but the main objection to them is in the uncertainty of their strength—some sustaining a very large amount of firing, while others yield at very much less. These guns are received from the founder, all manufactured of the same metal and with the

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same precautions, and all looking equally beautiful; and yet, on proof, many burst.

One gentleman, an officer of experience, quoted cases of the vast number of rounds which two or three individual guns had sustained; but they must be held as exceptions and not as establishing a rule.

After the experience of launching the Great Eastern we think that few Engineers, where extraordinary efforts were required, would now trust to cast iron for hydraulic presses.

The principal plea for the employment of cast-iron is that of turning to account the large stock in hand by rifling them; but even that plea is insufficient when the consequence will be a decidedly inferior article. And then it must be remembered that the shot and shells, which are by far the largest item in hand, will not form a part of the compromise, but will be entirely obsolete and only of the value of so much crude metal.

Brass guns are much more costly; but as they could be made much lighter, they were adopted for service in the field for the greater facility of transport; they did admirably for field pieces, that is, up to the 12-pounder, but failed for heavier guns.

Brass guns, however, were used till very modern times for battering-trains, in consideration of their lightness for drawing over difficult countries, or, at all events, when means of transport were always a very serious difficulty with an army; and although the system of firing them not oftener than five or six times per hour was laid down in books, the reason had been so far lost sight of that, during experiments tried at some French fortress on other objects, shortly before the Revolution, some heavy brass guns were fired rapidly, and gave way. The contractors who furnished them were brought to account, but were exonerated on proving the perfection of their metal and mode of manufacture.

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This gave rise to distinct trials and investigations, when the truth was again discovered; but the Revolution then breaking out, and throwing everything into confusion, no decision was arrived at, and the result was not generally promulgated or known.

In 1811, for the first siege of Badajos, we procured a battering-train from the neighbouring Portuguese fortress of Elvas, the guns being of brass, 18 or 24-pounders. Time was very limited, batteries for breaching hastily constructed, and the firing rapid and continued: the guns very generally failed, not by bursting, but by bending, the bores no longer remaining straight. The failure was attributed to the imperfection of Portuguese manufacture, whereas it was due to the properties of the metal, which will not stand the amount of heat generated by the continued explosions of such large charges.

At our subsequent sieges, we used cast iron guns, not so much even then from being fully aware of the weakness of the brass, as because they could be more readily obtained, and were so much cheaper; the consequence, however, was rather striking, for the iron guns bore the most continuous firing, and most of them remained serviceable for the period of a siege; and this was one leading element in enabling the operations to be carried through so rapidly that, in an intercepted letter fron Marmont (himself an artillery officer,) he professed not to be able to understand how the siege of Ciudad Rodrigo could have been brought to a conclusion so early.

The reduced charges of rifled guns, and the breech loading, will greatly reduce the heating of the gun, but will probably not entirely get rid of the evil; and, as the other metals, and modes of manufacturing guns will, without being more costly, possess qualities superior to those of the brass, and will certainly remove the defect, we may consider the days of brass guns to be numbered. With regard to the other metals

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and modes of giving them strength, they are of such novel introduction that we can scarcely reason much at present on their comparative meiits.

So far as the trials have yet gone, they all seem to be capable of being made of great lightness, and of a tenacity to withstand a great amount of firing; though more proof might be desirable with the heaviest calibres in this last item.

Other qualities, however, have still to be investigated.

The principal systems of rifling are the oval, the polygonal, and the grooved; the two former may be called smooth bores, may have their missiles of one hard metal, and may be made to load from the muzzle as well as the breech; the grooved requires a missile coated with lead or other yielding material, and must be loaded at the breech.

All of them have given great results in length of range, low angles of elevation, and precision of fire; some with greater perfection than others,—a matter of much value certainly. But other properties, such as durability, simplicity, and cost, must also be compared; for, putting an extreme case, that where all gave great results, and the one that produced the best effect in shooting, was far inferior in the other properties, it would reasonably be rejected on that account; therefore, the shooting qualities, the only ones as yet thoroughly tested, or even much enquired into, are not conclusive.

By durability is not meant alone the power of withstanding the effect of any amount of being fired, but ordinary wear and tear, also that of atmosphere by exposure for lengthened periods, and degrees of rough usage; to all of which under every reasonable precaution they must be liable.

By simplicity is meant a form and mode of construction and manufacture, that can be ensured at all times in equal perfection and in large quantities; for it is not sufficient to show effects that can be only produced by a beautiful and

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elaborate effort of art, not capable of being indefinitely multiplied, with rapidity, and to the same perfection.

Relative simplicity is also to be considered in the several parts of which the piece may be composed, and in what is required in its service.

Cost, to a certain degree, is of the least consequence.

There is scarcely any extent of outlay to procure superior perfection in warlike implements that is not only justifiable, but thoroughly economical, in the indirect bearings which they may have on success in war, and perhaps with smaller means; and the greater expense absolutely necessary to attain this perfection we may suppose should be in favour of our country, which can best afford it, and which, by its foreign possessions, and many holds of minor importance, is best able to turn to account obsolete articles during a period of transition.

But, cost is of importance when not absolutely necessary to obtain an adequate amount of benefit. Thus, if there be only very moderate advantages in one system over another that can be procured at far less cost, then the expense will form a very influential item in the comparison.

In estimating the relative value of different systems, these properties of durability, simplicity of construction and use, and of cost, will be subjects for consideration with regard to the shot and shells, equally or even more so than as regards the gun; for they are required by hundreds of thousands, and ought to be such as will always be rough and ready, and efficient; and here, there is an inconvenience that pervades them all, which is the superior care that will now be required for them.

The old spherical shot and empty shells could be manufactured almost anywhere; they were knocked about in all directions, and with a little paint now and then remained for years piled in the open air. The new must be treated differ-

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ently; they are of a more refined manufacture and must be housed, and perhaps require more or less even additional precautions to preserve them in an efficient state; and in this will be another element of relative value.

Artillery officers, from practice and experience, attach great consequence to the utmost degree of strength and simplicity in all the appendages and apparatus for working the guns; they find loose or separate parts objectionable, and require the adjuncts and appurtenances to be of as much solidity and as little in projections liable to accidents, as possible.

In most of the new guns, to produce the most striking effects in competitive or other trials, a refined system of sights and elevating and tangent screws have been applied, that at once give an appearance of liability to be disturbed; this might prove very objectionable unless they be so contrived that if accidents should occur to them the piece would be still quite serviceable, and still be capable of being used with great precision, although not quite to the utmost perfection attainable with them; and for this reason it will be of great importance to prepare the gun for the best service possible independent of them.

There is much contention on the part of the advocates for each gun as to priority of invention, the assumed borrowing from one another, &c.; it is to be hoped that some satisfactory arrangements may be made, to enable the final system for adoption to partake of whatever may be preferable in each, so as to make up as perfect a whole as possible.

As regards the effect of the rifled guns in actual warfare, it is evident that, combined with the improved rifle musket, it will require many changes in the principles hitherto practised.

We can as yet have but vague ideas on the subject. Much will have to be established by actual practice in war; few are competent yet to reason deeply upon it. Still, we cannot be too early in considering it in all its several bearings.

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Among the first impressions that strike us will be, that masses of troops cannot be exposed to open view at rest, or in deliberate movements, as they have hitherto been.

In contemplating the terrific effect of these guns, we complacently adopt a kind of impression of a calm unobstructed service by them on a quiescent enemy; whereas, the result will no doubt be in action that, to reduce its destructive fire, artillery will hereafter act against artillery more than has hitherto been permitted, more ammunition will be expended; and that which shall carry the greatest number of rounds per gun will have a great advantage. But the influence of even the new artillery will be greatly reduced by the power of the rifle musketry against it.

We do not expect that its effects on attack and defence of fortifications for their absolute reduction will be so great as first impressions would lead to believe. For all cannonading that can be effective at considerable distances, and where near approach is not attainable, it will be very valuable; but all good works are so covered, that to force them, it is absolutely necessary to close with them and in close action no advantage is gained by the new weapon.

In enfilade and ricochet their capabilities have yet to be proved.

To vertical fire also (an important item in sieges) no attention has yet been turned, though no doubt a valuable system for it will soon be established.

In contests between shore batteries and shipping, these guns will be very essentially in favor of the former, from their great power and precision. They will also afford a perfectly new facility for cannonading from very long distances any great open space that may be exposed to view, though perhaps perfectly protected against close approach. Thus, arsenals and other valuable establishments may be ruined from distances never hitherto contemplated as possible;

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and to prevent which will require an enormous development of defences.

One consequence that will surely arise from the introduction of the rifled guns, though at present resisted, will be the substitution of much lighter pieces for the great mass of the field artillery with an army.

The field pieces were formerly chiefly 6 pounders, and were gradually augmented to 9 and 12 pounders, not on account of the weight of shot hitting a heavier blow, which against troops would be worth nothing; but to obtain superior ranges, low angles of elevation, and general precision of fire,—all of which are now as good with the 3 as the 12-pounder; while the weight of the piece, and what is of much more importance, of the ammunition, is so much less, that two horses will transport as many guns and rounds of ammunition in the one case as would require from 4 to 8 in the other.

The only objections stated are in size of shell, and effect in hitting guns or carriages; and these would be more than compensated by the greater numbers fired.—*Army and Navy Gazette, 24th March* 1860.

Rules to find the variation of the Compass by observation of the Sun's amplitude, and of the Sun's Azimuth.—Communicated by Captain G. Carleton, Adjutant Horse Brigade Madras Artillery.

To find the variation of the Compass by observation of the Sun's amplitude.

Rule.—Longitude of place of observation being known, and exact time of observation being noted, find its corresponding time at Greenwich, and to that time reduce the Sun's declination given in the Nautical Almanack for *Noon* at Greenwich. The correction of time at place of observation to time at Greenwich is simply made by allowing at the rate of 60 minutes of time for every 15° of Longitude, that the place of observation is *E* or *W* of Greenwich, if *E* of Green-

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wich the time will be before Greenwich time and all differences must be deducted, and vice versa.

N. B. It must be observed if declination in Almanack is on the increase or decrease, then should the observation be made at a time which (when corrected for difference of longitude) is found to be afternoon at Greenwich, the difference of declination is to be added to that taken from the Almanack if declination be increasing, and subtracted if it be decreasing, should the observation have been made at a time, which corrected for difference of longitude, turns out to be before noon at Greenwich, the addition and subtraction here spoken of are to be reversed.

2nd. The latitude of place of observation being known, add the log. *Sine* of Sun's reduced declination to the log *Secant* of said latitude, the Sum will be the log. *Sine* of the *true* amplitude, to be counted from the *E* in the morning, and towards the North or South, according as the declination happens to be North or South, and from the *W.* in the afternoon, and towards North or South again according to declination.

3rd. Now if the true and magnetic amplitudes be both North or both South, their *difference*, but if one be North and the other South, their *Sum* will be the variation, and to know whether it is Easterly or Westerly, let the observer look to that point of the compass which represents the magnetic amplitude, in this case 25° 30′ from West towards South, and if the true amplitude be to the right of it, variation is ***East***, if to the left it is ***West***.

Example 1.—At Secunderabad 21st December 1857 observed Sun's amplitude at setting to be *W.* 25° 30′ *S.*

Latitude	17° 30′ *N.*	log. Secant	0·02059
Declination	23° 27′ 34″ S.	log. Sine	9·59999
true amplitude	*W.* 24° 40′ 2″ S.	log. Sine	9·62058

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observed amplitude W. 25° 30′ S.
true „ W. 24° 40′ 2″ S.

Variation Easterly 49′ 58″ the true amplitude being to the right of the magnetic.

Note.—The declination above has not been corrected for time at Greenwich corresponding to the time at place of observation when observation was made, it was not considered necessary, as the difference for 24 hours from noon 21st to noon 22nd is shewn in Almanack only 5″, while time of observation was but a few minutes past noon at Greenwich on 21st.

Example 2nd.—At Bangalore 18th December 1858, at 5h. 41m. 15s. P. M. Latitude as calculated from Meridian Altitude of Sun same date, 12° 53′ 14″ N.: observed amplitude at sunset to be W. 24° 40′ S.

Latitude 12° 53′ 14″ N. Secant................ 0·0110796
Declination corrected to Greenwich time
23° 24′ 35″ S. Sine.................. 9·5991225

True amplitude W. 24° 3′ 8″ S. Sine... 9·6102021
Observed amplitude W. 24° 40′ S.

Variation is 36′ 52″ East, the true being to the right of the magnetic *amplitude*, this is less than the ⅓th of a point, there being 11¼° to every point of the compass.

The instrument used in the above observations was a pocket compass, in using which it is necessary to note how the compass card is divided. Some are divided 180° from North to South by the East, and again 180° commencing from South to North by the West, in which case suppose a Sun's bearing in afternoon reads 65° 20′ from South towards the North, as we must reckon the bearing in an amplitude from the West in the afternoon, or the East in the forenoon, it is in this case necessary to subtract 65° 20′ from 90°, which is

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exactly West, and the difference 24° 40′ counted in this case from West towards the *South*, as sun's declination, is South, will be the observed or Magnetic Amplitude. Should the observation be made at Sunrise, and the bearing read 113° 20′ from the North by the East, subtract 90 which leaves 23° 20′ from the East towards the South, or *E.* 23° 20′ *S.*

Note.—The magnetic *amplitude* of a celestial body is its bearing from the *magnetic* East or West when it is rising or setting. The true amplitude is the degrees and minutes &c. the object rises or sets to the Northward or Southward of the *true* East or West, owing to the want of a true horizon, amplitude observations cannot be depended upon for perfect accuracy ashore, and the artificial horizon cannot be applied. The observation should be made when the Sun's lower limb seems about the height of his semi-diameter above the horizon, his centre being then in the horizon, though by refraction it is made to appear higher: the higher the latitude and the denser the atmosphere the greater is the influence of refraction, which causes the sun to appear above the horizon about 33s. too soon in rising and too late in setting; refraction is proportionably greater as the body observed is further from the zenith, at the zenith there is none, at the horizon there is the greatest amount of refraction.

To find the variation of the Compass by an observation of the Sun's Azimuth.

The magnetic or observed azimuth of a celestial object is its bearing from the North or South when it is above the horizon, but when this bearing is being taken the altitude of the object must also be observed, and as nearly as possible at the same instant in order to calculate the true azimuth ; in other words the azimuth of a celestial body is the angle at the zenith formed by the meridian of place of observation and another vertical circle passing through the centre of the celestial body, and the azimuth is measured by the arc of the

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horizon intercepted between the aforesaid meridian and aforesaid verticle circle—as amplitude is counted from the *E* or *W* points of the horizon so azimuth is reckoned from the *N* or *S* points of the same, the former is the complement of the latter.

RULE.—Longitude of place of observation being known and exact time of observation of altitude and bearing being noted, find the time corresponding at Greenwich, and to that time reduce the Sun's declination on date of observation which will be found in the Nautical Almanack for *Noon* at Greenwich, this has been previously described, compute also the Sun's true altitude.

2. *Subtract* the corrected declination from 90° when latitude of observer and Sun's latitude or declination are both North or both South, but *add* the same to 90° when latitude and declination are the one North and the other South, the sum or remainder respectively will be the Sun's polar distance *P. D.* vide diagram.

3. Add the Sun's *true* altitude, the latitude of place of observation, and the Sun's polar distance, and take the difference between *half* their sum and the polar distance noting the remainder,

4. Now add

The log. secant of the altitude
" " " latitude
The log. cosine of the half sum
and the log. cosine of the remainder.

5. Half the sum of these four logarithms will be the sine of an arc, which multiply by 2 for the Sun's *true* azimuth to be reckoned from the *South* in *North* latitude and from the North in South latitude, towards the East in the morning and towards the West in the afternoon.

6. If the true and observed azimuths be both reckoned from the North or both from the South, their difference is the variation, but if one be reckoned from the North and the

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other from the South, subtract the true azimuth from 180° and the difference between the remainder and the magnetic azimuth will be the variation; and to know if it be East or West let the observer look towards the point of the compass represented by the magnetic azimuth, then if the true azimuth be to the right of the magnetic the variation is East, but if to the left it is West.

N. B.—In observing Sun's altitude ashore an artificial horizon must be used and the altitude read from it will of course be the double altitude and must be divided by 2, first deducting or adding index error if there be any.

The observation is generally made from Sun's lower limb, to observe which bring the images of the sun into contact in the artificial horizon without allowing them to overlap at all. When the contact is formed at the lower limb the images will separate soon after the contact has been made if the altitude be *increasing* but if it be *decreasing* they will overlap.

EXAMPLE 1.—At Secunderabad 22nd December 1857 at 7h. 46m. A. M. Observed double altitude of the Sun to be 31° 55′ Observed or Magnetic Azimuth *N.* 120° 50′ *E.* To find true azimuth.

Observed altitude $\frac{31° \ 55'}{2}$ =	15°	57′	30″	
Deduct Refraction—		3′	21″	
	15°	54′	9″	
Add Parallax +			8″	
	15°	54′	17″	
* Add Sun's semi-diameter found in Nautical Almanack +		16′	18″	
True altitude of Sun's centre	16°	10′	35″	
Latitude of Observer	17°	30′		
Sun's polar distance	113°	27′	31″	Subtract.
2)	147°	8′	6″	
Half sum	73°	34′	3″	

*had Sun's upper limb been observed, his semi-diameter should have been subtracted. Now from polar distance take the half sum and the remainder is 39° 53′ 28″ the log. cosine of which together with the log. cosine of the half sum add to the log. secant of the latitude and log. secant of the Sun's altitude.

as altitude	16°	10′	35″	log. secant	0.01754
latitude	17°	30′		log. secant	0.02059
half sum	73°	34′	3″	log. cosine	9.45161
remainder	39°	53′	28	log. cosine	9.88494
					2)19.37468
Arc 29° 7′ 47″				Sine	9.68734

2

58° 15′ 34″ Sun's true azimuth from the South.

Lastly from 180°

take *S* 58° 15′ 34″ *E*. the true azimuth from South.

and from *N* 121° 44′ 26″ *E* do. do. North.

take *N* 120° 50′ *E* observed azimuth from North,

and variation is 54′ 26″ East the true azimuth being to the right of the magnetic.

the $\frac{1}{13}$ part of a point in the compass, there being 11° 15′ in each point.

* The declination taken from the Nautical Almanack for the day is 23° 27′ 31″ and it is here *added* to 90° to find the polar distance 113° 27′ 31″ as the observer is in North latitude, the Sun being in South, that is his declination being South.

N. B.—The Nautical Almanack referred to is Hannay's Royal Almanack published every year and sold at home for sixpence. The instruments used were the common pocket Compass fitted with dark glasses and the pocket Sextant with an Artificial horizou.

Example 2.—At Bangalore December 14th 1858. Longitude 77° 35′ *E*. Latitude 12° 53′ 14″. Time of observation

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8h. 27m. 37s. A. M. Observed azimuth counting from the North $N.$ 123° 42′ 30″ $E.$ or $S.$ 56° 17′ 30″ $E.$ counted in each case towards the East as observation is made in the morning. Required to find true azimuth.

The difference in declination in 24 hours is at this time of year so small that it is hardly worth while in a rough calculation to correct it, for as in the present case 8h. 42m. 43s. from noon on 13th to noon on 14th the difference of declination was but 3′ 47″ the noon of preceding day is taken, and as the declination is increasing the amount that it wants to equal that at noon on 14th is deducted from 23° 14′ 3″ as the observation is made in the forenoon and the time when corrected is also before noon at Greenwich, at the risk however of being excessively prosy the method is gone through piecemeal as follows:—Longitude of Bangalore 77° 35′ $E.$ of Greenwich, which calculated in time at the rate of 15° for one hour makes us 5h. 10m. 20s. before Greenwich, deducting this from the time of observation at Bangalore gives the corresponding time at Greenwich as 3h. 17m. 17s. A. M.

The declination at Noon 14th at Greenwich was 23° 14′ 3″ corrected for 3h. 17m. 17s. A. M. or

8h *42m* *43s* short of noon on that date is	1′ 22″*
Corrected declination	23° 12′ 41″

(* declination differs between 13th and 14th only 3′ 47″ according to Almanack, i. e. for 24 hours.)

Now as Observer is in *North* Latitude and Sun's declination is *South* 90° must be *added* to the corrected declination to get the polar distance, PD then is equal.	113° 12′ 41″

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Now to correct the observed altitude

Observed altitude after dividing by 2 is	25° 52′ 15″
Deduct refraction	1′ 59″
	25° 50′ 16″
Add Parallax	8″
	25° 50′ 24″
Add semi diameter	16′ 17″
Sun's true altitude	26° 6′ 41″

Note.—1 hour of time = 15° of space.
1 minute of time = 15′ of space.
1 second of time = 15″ of space.

Next add Sun's polar distance		113° 12′ 41″
True altitude		26° 6′ 41″
and latitude of Observer		12° 53′ 14″
		2)152° 12′ 36″
Cosine 9.3804705	of ½ sum	76° 6′ 18″
Cosine 9.9017398	of remainder	37° 6′ 23″
Secant 0.0467525	of Altitude	26° 6′ 41″
Secant 0.0110796	of Latitude	12° 53′ 14″
2)19.3400424		
Sine 9.6700212	of 27° 53′ 19″	
	2	

S 55° 46′ 38″ *N* true azimuth
S 56° 17′ 30″ *N* Observed azimuth

Variation 30′ 52″ *E*

the true azimuth being to the right of the magnetic, supposing observer to be looking in the direction of the latter. The latitude assumed above viz 12° 53′ 14″ was worked from

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Meridian altitude of the sun, but 12° 57′ *N.* is laid down on old authority as the latitude of Bangalore, and may be the more correct; working upon this latitude the variation comes out 33′ 40″ *E.*; the variation as found by either amplitude or azimuth very nearly coincides in every case and with the assistance of another person in making the observations the Sun's azimuth bearing at the time his altitude was observed could have been simultaneously noted, this was not done in the foregoing observation, but the following directions if attended to will enable a single observer to calculate it pretty exactly, and will obviate any hurry in observing.

1st Take the sun's bearing either from North towards South or vice versa and note carefully the time by watch.

2nd Take his altitude and note exactly the time by watch at the moment of contact of the direct and reflected images in the artificial horizon.

3rd Take his bearing again and note the time as before, from these his magnetic bearing at the moment of contact can be computed thus, suppose.

1st bearing at	5*h* 22*m* 20*s*	was *S* 106° *W.*					
2nd do.	5*h* 31*m* 30*s*	was *S* 107° 20′ *W.*					
and	5*h* 25*m* 25*s*	was the time of contact.					
then from	5*h* 31*m* 30*s*		107° 20′		5*h* 25*m* 25*s*		
take	5*h* 22*m* 20*s*		106°		5*h* 22*m* 20*s*		
and say	9*m* 10*s*	:	1° 20′	::	3*m* 5*s*		
	60		60		60		
	550*s*	:	80	::	185*s*	:	26′ 54″

So 26′ 54″ is the difference between his 1st bearing and his bearing at time of contact, and if it be added to his 1st bearing we have his magnetic or observed azimuth bearing at time of contact *S.* 106° 26′ 54″ *W.*

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Again suppose 1st bearing at $8h.$ $40m.$ was S 59° 30′ E.
2nd „ $9h.$ was S 53° 30′ E.

and time of coutact was $8h.$ $53m.$

then $9h.$	53° 30′	$8h.$ $53m.$
$8h.$ $40m.$	59° 30′	$8h.$ $40m.$

$20m.$: 6° :: $13m.$: 3° 54′ the difference between his first bearing and his bearing at time of contact;

So from 59° 30′
take 3° 54′ as bearing was decreasing

and 55° 36′ is magnetic bearing at the time of taking the altitude by Sextant.

Another method of calculating variation of compass from an azimuth observation is as follows:—

1st Find the Sun's true zenith distance by taking his true altitude found as before from 90°.

2nd Find his polar distance by *subtracting* his corrected declination from 90, should latitude and declination be both North or South, or by adding the declination to 90° should one be North and the other South.

3rd Find Co latitude of place of observation by subtracting latitude from 90°.

4th Add zenith distance, polar, distance, and Co latitude together and take the difference between half their sum and the polar distance noting the same as remainder.

5th Add the log. sine of the half sum above mentioned and log. sine of the remainder. Add also the log. sines of Co latitude and zenith distance, and subtract the latter sum from the former.

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6th Halve this remainder and we have the log. cosine of an arc which doubled will be the Sun's true azimuth from the North in North latitude, and from the South in South.

EXAMPLE.—Bangalore 14th of December 1858. Latitude 12° 57′ *N*. True Altitude of Sun 26° 6′ 41″. Time of observation 8h. 27m. 37s. A. M.—Observed azimuth counting from the North, *N*. 123° 42′ 30″ *E*. Longitude 77° 35′ *E*. noted for the correcting of declination in finding polar distance.

From the foregoing data is found.

Zenith distance	63° 53′ 19″	
Co latitude	77° 3′	
Polar distance	113° 12′ 41″	
	2)254° 9′ 00″	
½ sum	127° 4′ 30″	Sine 9.901919
remainder	13° 51′ 49″	Sine 9.379586
Zenith distance	63° 53′ 19″	Sine 9.953247
Co latitude	77° 3′ 00″	Sine 9.988811
		9.281505
		9.942058
		2)19.339447
	62° 7′ 55″	Cosine 9·669723
	2	

N 124° 15′ 50″ *E* true azimuth from North.
N 123° 42′ 30″ *E* observed „ „ „

Variation 33′ 20″ East, the true being to the right of the observed; by the former method working with the same latitude 30′ 40″ was the result, and with latitude assumed to be 12° 53′ 14″ *N* 30′ 52″ was the result.

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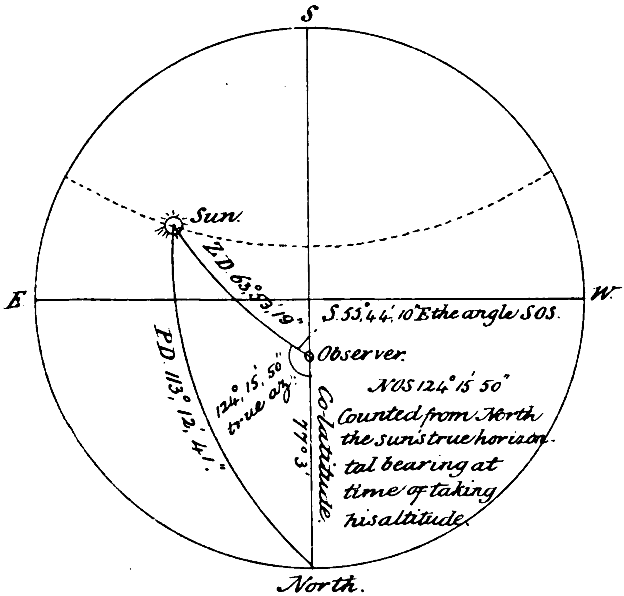
DIAGRAM TO ILLUSTRATE THE FOREGOING REMARKS.



The Compass variation at Madras in 1840 is stated to have been 1° *E* and at Bombay ½° *E* while at Calcutta it was 3° *E*.

Here *Z. D.*, *P. D.*, Co latitude are the 3 sides of a spherical triangle given to find the angle opposite *P. D.*

N. B.—The latitude of Bangalore was probably originally taken from the Fort, which is at least between 2 and 3 miles South of the Horse Artillery Barracks, and the Cantonment latitude may be assumed at 12° 59′ or 13° *N.*

(Signed) G. CARLETON, Capt.,
Adjt. H. A.

7th Jan. 1859.

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Short useful Tables not found in the 6d. Astronomical Almanack.

Apparent altitude.	Refraction.	Apparent altitude.	Refraction.	Apparent altitude.	Refraction.	Apparent altitude.	Refraction.
1° 00′	24′ 21″	40′	7′ 45″	20′	4′ 21″	38°	1′ 14″
10′	23′ 10″	50′	7′ 35″	30′	4′ 17″	39°	1′ 12″
20′	22′ 3″	7° 00′	7′ 25″	40′	4′ 14″	40°	1′ 9″
30′	21′ 2″	10′	7′ 15″	50′	4′ 11″	41°	1′ 7″
40′	20′ 5″	20′	7′ 6″	13° 00′	4′ 8″	42°	1′ 5″
50′	19′ 12″	30′	6′ 58″	10′	4′ 4″	43°	1′ 2″
2° 00′	18′ 22″	40′	6′ 50″	20′	4′ 1″	44°	1′
10′	17′ 36″	50′	6′ 42″	30′	3′ 58″	45°	58″
20′	16′ 53″	8° 00′	6′ 34″	40′	3′ 56″	46°	56″
30′	16′ 13″	10′	6′ 27″	50′	3′ 53″	47°	54″
40′	15′ 36″	20′	6′ 20″	14°	3′ 50″	48°	52″
50′	15′ 1″	30′	6′ 13″	15°	3′ 34″	49°	51″
3° 00′	14′ 28″	40′	6′ 6″	16°	3′ 21″	50°	49″
10′	13′ 57″	50′	6′ 0″	17°	3′ 9″	51°	47″
20′	13′ 29″	9° 00′	5′ 54″	18°	2′ 58″	52°	46″
30′	13′ 1″	10′	5′ 47″	19°	2′ 48″	53°	44″
40′	12′ 36″	20′	5′ 42″	20°	2′ 39″	54°	42″
50′	12′ 11″	30′	5′ 36″	21°	2′ 31″	55°	41″
4° 00′	11′ 48″	40′	5′ 30″	22°	2′ 23″	56°	39″
10′	11′ 27″	50′	5′ 25″	23°	2′ 17″	57°	35″
20′	11′ 6″	10° 00′	5′ 20″	24°	2′ 10″	58°	36″
30′	10′ 47″	10′	5′ 15″	25°	2′ 4″	59°	33″
40′	10′ 28″	20′	5′ 10″	26°	1′ 59″	60°	34″
50′	10′ 11″	30′	5′ 5″	27°	1′ 54″	61°	32″
5° 00′	9′ 54″	40′	5′	28°	1′ 49″	62°	31″
10′	9′ 38″	50′	4′ 56″	29°	1′ 45″	63°	30″
20′	9′ 23″	11° 00′	4′ 52″	30°	1′ 41″	64°	28″
30′	9′ 9″	10′	4′ 48″	31°	1′ 37″	65°	27″
40′	8′ 55″	20′	4′ 44″	32°	1′ 33″	70°	21″
50′	8′ 42″	30′	4′ 40″	33°	1′ 30″	75°	16″
6° 00′	8′ 30″	40′	4′ 36″	34°	1′ 26″	80°	10″
10′	8′ 18″	50′	4′ 32″	35°	1′ 23″	85°	5″
20′	8′ 7″	12° 00′	4′ 28″	36°	1′ 20″	90°	0″
30′	7′ 56″	10′	4′ 24″	37°	1′ 17″		

Dip. — *Sun's Parallax in Altitude.*

feet.		feet.		feet.		Altitude.	Parallax.
1	0′ 59″	11	3′ 14″	21	4′ 28″	00°	8½″
2	1′ 23″	12	3′ 23″	22	4′ 34″	20°	8″
3	1′ 41″	13	3′ 31″	23	4′ 41″	34½°	7″
4	1′ 57″	14	3′ 39″	24	4′ 47″	45°	6″
5	2′ 11″	15	3′ 47″	25	4′ 53″	54°	5″
6	2′ 23″	16	3′ 54″	26	4′ 58″	62°	4″
7	2′ 35″	17	4′ 1″	27	5′ 4″	70°	3″
8	2′ 45″	18	4′ 8″	28	5′ 10″	76°	2″
9	2′ 56″	19	4′ 15″	29	5′ 15″	83°	1″
10	3′ 6″	20	4′ 22″	30	5′ 20″	90°	0″

Rule to calculate Sun's parallax for any altitude.

To the log. cosine of the Sun's apparent altitude add the log. of the Sun's mean horizontal parallax 8″ 5776, reject 10

from the index and the remainder will be the *log*. of the Sun's parallax in altitude in seconds.

Example.—Find parallax when apparent altitude is 60°.

	8″ 5776 log.	0.933366
apparent altitude	60° cosine	9.698970
Sun's parallax in altitude	4″ 28 log.	0.632336

Rule to calculate the table for depression of the horizon or dip.

To the log. 3.609990 add log. of the height of the eye above the plain in feet, half this sum will be the log. of dip in seconds, from which deduct $\frac{1}{11}$ for refraction.

Required dip for 150 feet.

	150 feet log	2.176091
	Constant logarithim	3.609990
12)781″ 7		2)5.786081
65″ 1		2.893040
716′ 6=11′ 57″ dip required.		

Note.—Refraction and dip are always to be subtracted—Parallax added. Sun's semi-diameter is added, or subtracted, according as his lower or upper limb is observed: Equation of time is sometimes added, sometimes subtracted, according to the time of year; this is shewn in the Nautical and also in Hannay's Six penny Almanack.

(Signed) G. Carleton.

Mr. Whitworth's Rifled Cannon.

To the Editor of the "Times."

Sir,

The results of the experiments recently made with my rifled cannons at Southport, have elicted notices and comments which I think require me to make some explanation.

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My rifled guns have not been made expressly with the view of obtaining great range; that is one of the advantages they possess, but it is not obtained at the sacrifice of others.

They are all adapted, not only for firing solid shot, but also for hollow shot, which may be filled with molten iron, and for every description of shell. The capacity of the shell is easily increased by adding to its length; and, as my guns are rifled throughout, and require no chamber, shells of any length may be fired with any requisite charge of powder.

The tables of results published in the newspapers were, in some instances, arranged by the gentlemen who reported them, in increasing or decreasing order; but the numbers prefixed do not indicate the order in which the shots were fired.

This arrangement may have produced an impression that the ranges, in certain cases, gradually diminished. This was not the case, in some series the longest ranges were attained by the last shots fired, and the piece, as it was warmed by the discharges, became cleaner than it was after the first or second shot.

The fact that the ordinary cast-iron service guns which I rifled, as an experiment, in 1858, proved too weak to be used as rifled pieces, has been much dwelt upon; and it was, perhaps, an error of judgement to apply my system experimentally to the cast-iron blocks without strengthening them. I may mention that the service cast-iron 68-pounder rifled by me, when tried at Portsmouth, in 1858, propelled my flat-fronted shot through one of the 4 inch wrought iron plates, and also through the ship's side on which they were firmly bolted, the range being 450 yards. In no other instance, I believe, has a single shot been driven through the 4-inch plate. The experiment was not repeated, as the cast-iron gun burst.

All the guns, however, which I have myself made are ready for any proof, and any comparison, that may be required.

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Their strength, is such that they can be elevated on their carriages, and be fired, if necessary, as mortars, at any angle, with the largest charge of powder than can be consumed in them.

The 3-pounder was repeatedly fired at an angle of 35-deg., and attained a range of more than five-and-a-half miles, without doing the piece or its carriage the slightest injury.

These guns being stronger than is practically necessary, there would be no gain in adding to their strength, though I could do it if it were requisite.

The material of which the cannon is made is the same as that used for my rifled musket barrel-homogeneous iron. To obtain an extreme proof of its strength, I loaded one of the barrels with a leaden plug, so long that a full charge of powder was unable to drive it out. On firing the powder, the plug remained in the barrel, and the gases of the explosion all came through the touch-hole, leaving the barrel uninjured. This experiment was repeated four times with a similar result.

The brass howitzer guns which I rifled for the Government in 1856, stood every proof to which they were subjected. I could not now improve upon them as muzzle loading guns, and feel confident that they are as efficient as any rifled cannon of like calibre that have been made. In fact, of the rifled cannon, as of the rifled musket, constructed on the principles which I have adopted, it may be said that, practically, they must all shoot alike—a result which necessarily follows accurate measurment, and workmanship in making them.

I have had no wish to make a special gun, any more than to choose out special experimental results. Records of all the shots fired during our late experiments were taken by disinterested spectators, and have been published in several journals. The merits of the system have, I believe, been thoroughly tested and may now be fairly judged.

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The practice with the smallest gun, the 3-pounder, proved all I wished to establish in point of range, it was, therefore, not requisite to surpass it with the heavier cannon fired at a high elevation.

Of the durability of my guns, I can speak with the utmost confidence. Being made of the harder and tougher homogeneous iron, they must be more durable than forged guns, made of comparatively soft and fibrous wrought-iron. From one of them upwards of 1,500 shots have been fired, chiefly at high elevations, without the gun exhibiting any injury or sign of wear.

The breech-loading arrangements are so simple that they are not easily injured.

The guns fired at Southport had all been standing on the open shore, exposed to the action of sea air and drifting sands for some weeks, most of them during the whole winter.

The relative merits of my own and other systems are best compared by appealing to practical results. These show that the system of construction which enables the simple hard metal projectile to be fired, gives better results, and is capable of a more extended application, than the construction which requires the compound projectile and soft metal coating. In other words, the system of rifling by mechanical fit is capable of doing much more than that of rifling by the force of the explosion.

The latter is a construction of which I cannot be said to have approved, otherwise I should have adopted it. Among other objections to the use of the compound coated projectile, one of great importance is, that it involves an arrangement which is complicated, whereas the shaped, hard metal projectile is far more simple, and may be produced at less cost. Simplicity of arrangement and construction is the special object I sought to obtain, knowing that in this, as in all other improvements based on mechanical principles, that system is the most perfect which is reduced to its simplest elements.

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When this is done successfully, it may generally be considered that the result cannot be surpassed.

With regard to the cost of my rifled musket, which has been stated to be an impediment in the way of its adoption for the service, I may state that there would be no difficulty in adapting the machinery and plant already in operation at Enfield, or any requisite portion of it, for making rifles on my system. The change would not cause an increase in the manufacturing expenses; and, supposing the quality of the workmanship and materials to remain the same, the advantages arising from the use of my bore, and turn, and hard metal projectiles, would double the efficiency of the rifle without increasing its cost.

At the same time I am of opinion that by going to a slight extra expense in manufacturing the barrel more carefully, a better rifle may with advantage be supplied to the service.

This is what I recommended some time ago to the Government, when I offered them my services, gratuitously, in aiding to adapt the Enfield establishment to the production of rifles on my system.

It is true that I proposed to supply for the use of the service some rifles at a cost of £10, but these were to be all superior weapons, well finished, and in shooting qualities equal to my other rifles. It would not, however, be fair to take this sum as representing the cost of manufacturing military weapons on a large scale, in a completely organised establishment. The offer involved considerable pecuniary sacrifice, considering that the means of supplying the demand for my rifles are at present limited, and it arose from the desire which I always had, and still feel, of rendering all the assistance I can in arming our soldiers with the most efficient weapon.

I remain, yours obediently

JOSEPH WHITWORTH.

Manchester, February 28, 1860.

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Mr. Whitworth's Rifled Cannon from the "Illustrated Lon News," 10th March 1860.

So much has been said and written upon the astonishing results obtained from Mr. Whitworth's cannon in his late experiments, that it will be unnecessary to do more than give a general account of what took place at Southport. Mr. Whitworth's experiments were made on the Sea-shore, between Southport and Liverpool. By the permission of the Admiralty, he availed himself of some six or seven miles of flat sea-shore, admirably adapted for testing the range of his guns, but not equally suited for target practice at long distances. The targets placed on the flat shore cannot be distinguished so as to enable them to be sighted at the great ranges to which the Whitworth cannon throws its shot. An eminence similar to that from which the cannon are fired at the Shoeburyness range is requisite.

The experiments were made on five different days, between the 15th and 24th ultimo. Southport, which is one of the most frequented of the Lancashire watering places, roused itself from its winter lethargy to witness the success of the great Lancashire Engineer and artilleryman. Crowds of visitors streamed along the flat shores, or climbed the sandy hillocks which fringe the low coast, and form a natural dyke against the incursions of the sea.

A small, open space on the shore, about two miles and a half from Southport, was marked out by cords and posts to restrain the press of the spectators, who were, moreover, duly kept in order by the inevitable police. In this space stood four Whitworth breech loading guns, mounted on their carriages. Two were 3-pounders, one was a 12-pounder, and one an 80 pounder. An 18-pounder was also on the sands, but it was not fired, as so much time was taken up by the experiments with the other guns.

We give in tables, which follow, the best results obtained by the Lancashire gun, and certainly they merit the appella-

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tion of "astounding" bestowed upon them by a leading morning paper. The smallest gun, a 3-pounder, weighing only 208 lb., threw a shot upwards of five miles and a half, and achieved more, in point of range, than any gun of any calibre that had before been tried, not excepting any made by Sir William Armstrong. He, on one occasion, succeeded in throwing a 32 lb. shot 5 miles and 170 yards, a range which neither he himself nor any one else exceeded until it was far surpassed by Mr. Whitworth.

It has since been said that precision, rather than range, was chiefly aimed at by Sir William Armstrong. It would seem likely, however, that the gun that was able to give its shot the best impetus for flight would also give it the truest impetus for precision. The statement, however, had the high authority of Mr. Sidney Herbert, who supported it in the House of Commons by giving what must be taken to be the best results in precision obtained by Sir W. Armstrong. Out of forty shots fired with the Armstrong 12-pounder, Mr. Herbert gave the results of 15, fired respectively at elevations of 7, 8, and 9 degrees. And here we may contrast this mode, so often adopted in recording artillery practice, of giving the results of selected shots, with that adopted in recording the experiments at Southport. The exact result of every shot fired there has been published, without any suppression or allowance for trial or wild shots, and without any selection of a favourable percentage of the hits made. This enables any one acquainted with the subject, even though not present at the experiments, to deduce correct conclusions from them. But to return to the account of the Armstrong 12-pounder, which it will be interesting to compare with the Whitworth 12-pounder, as to precision of fire as well as range. We quote Mr. Herbert's speech made in the House on Friday, February 17:—"The last gun made by Sir William Armstrong, and sent to be tried, was a 12-pounder. At 7 degrees of elevation, in five rounds, the range was from 2,465 yards to 2,495 yards, the difference in

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range being 65 yards, and the greatest difference in width three yards." With these may be compared the practice with a Whitworth of the same calibre (12-pounder), fired at the same elevation (7 degrees), on February 21, as appears from the table below. The range was from 3,078 yards to 3,107 yards, the difference in range being 29 yards, the greatest difference in width, 1¾ yard.

The range of the Whitworth at 7 deg. (3,107 yards) exceeded the Armstronge at 7 deg. range (2,495 yards) by 712 yards; it, in fact, exceeded the range obtained by the latter gun at 8 deg., and even 9 deg., and was therefore not fired at 8 deg. or 9 deg.

The shooting of the Whitworth 80 pounder at 7 deg. appears to have been still more accurate: the range attained was about two miles, and three out of four shots fell in an area of sixteen yards long, by 1 foot wide. This comparison at 7 deg. is sufficient to show that in precision, as well as in range, the Whitworth has proved itself the superior gun.

Objections have been made to the Whitworth cannon on the score that it does not fire shell; but if, as Mr. Whitworth states, it is adapted for solid shot, and still better for shell, and hollow shot filled with molten iron, the objection is without foundation. He also states that his guns are actually stronger than they are practically required to be, and may be fired as mortars, at any elevation, and with the largest charge of powder that they can consume. This was strikingly illustrated by the practice of the 3-pounder at Southport, when it was, with its carriage, elevated on a platform, and fired like a mortar at 35 deg. without injuring it in any way. This must be ascribed to the fact that the recoil in guns firing the mechanically-fitting projectiles from the polygonal bore is reduced to its minimum. The projectile is easily started, and, in familiar terms, soon acquires way when it is propelled through the smooth, well

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lubricated tube, and, as provision is made for keeping it as it issues perfectly concentric with the bore, it is propelled under the conditions most favourable as to range and precision, and also as to recoil. The bore, as is well known, is a spiral, hexagonal in section, the corners being rounded off. The pitch of the rifling, or the turn, is a rapid one.

The 3-pounder is 70 inches long, and, with a bore of 1 ½ inch, has one turn in 40 inches, and weighs only 208 lb. The 12-pounder, with a bore of 3·2 inches, has one turn in 60 inches. The 80-pounder, with a bore of ·55 inches, has one turn in 100 inches. The quick turn and reduced bore are recognised as being the special features in the Whitworth system, both for rifled cannon and the rifled musket,

All the cannon fired at Southport are breech-loaders. The breech end of the gun is closed, when charged, by a cap, screwed on something like a magnified top of a pencil-case, except that, being of larger proportions, it is turned by a handle. The cap is not detached, but works in a hoop, which is connected by a hinge-joint to the breech of the gun.

The method of charging and working the gun is as follows:—Two or three turns of the handle unscrew the breech-cap, which is received and supported in a hoop, and and is then swung back, or rather on one side, like an opened door, leaving the breech end of the gun exposed. The projectile is then pushed in, and behind it is inserted a tin cartridge-case, containing the powder, and shaped hexagonally to fit the rifled bore. The powder is kept in the cartridge-case by a wad or hexagonal cake of lubricating material, such as a mixture of wax and tallow. In the rear end of the tin case is a small orifice corresponding with the vent which is made in the centre of the breech-cap. The tin cartridge-case being inserted, the hinged hoop carrying the breech-cap is swung to in door fashion, and by turning the handle it is

screwed firmly on the rear of the gun. An ordinary friction fusee is then inserted in the vent, made, as stated, in the centre of the breech-cap, and the piece is discharged, generally in less than a minute from the time of beginning to load, and that without any attempt at hurry. When the piece is discharged there is no escape of gases from the breech; and when it is unscrewed and swung aside, the end of the tin cartridge-case is seized by hand, or by a suitable gripping instrument, and is withdrawn from the gun. The case thus brings away with it all the fouling deposits; and, as the barrel is completely lubricated by the lubricating wad, no sponging nor cleansing by water is required; in fact the shots, as they issue, clean the gun.

Next to the gun itself, the tin cartridge-case, whose convenience and utility were strikingly manifest, was most admired. Its suitableness for storeage and superiority over the old flannel bag were universally acknowledged.

It should be mentioned that, at different times during the continuance of the experiments, many military officers of high rank in our own and foreign services, and of acknowledged authority in matters relating to artillery were present.

Among the figures grouped round the gun in our illustration are represented Sir John Burgoyne, ever zealous on behalf of the service; the Hon. Captain Wrottesley; Colonel Campbell, who represented the Ordnance Select Committee; and Mr. Whitworth himself. Among the various foreign Governments who were represented we may mention the Russian, Brazilian, Danish, American, Swiss, and others, we are informed, who did not declare themselves.

The military men and engineers, who mustered in strong force to witness the Southport experiments, were as much

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pleased as surprised by the extreme simplicity of the breech-loading arrangements, and the ease and certainty with which the guns were worked. It is worthy of remark that, through all the five days' experiments, there was no instance of any delay caused by difficulty in loading, or by fouling, or fixing the breech, or any accident in the working of any of the guns. The experiments were necessarily very numerous. The shots were fired in groups, of various numbers. The place where each shot fell was marked by a peg, and afterwards carefully measured and recorded.

In some of the reported accounts the ranges are tabulated in decreasing or increasing order. This, it should be observed, gives no indication of the actual order of firing, of which no account was kept, as all the shots were measured at the end of the experiment to prevent loss of time.

Our space will not admit of our giving tables of all the experiments made; we have, therefore, chosen those which give the best and most interesting results, and which specially enable a comparison to be made between the Whitworth and Armstrong guns. We have in each table given the distance of every shot fired in the series or group forming the particular experiment. In some cases average distances are calculated from the ascertained centre of the group of shots fired, and are taken longitudinally and laterally. This is, in fact, applying to the horizontal area in which the shots fell the same principles on which the "figure of merit" is determined on the vertical targets at the Hythe School of Musketry. This method of calculation is the most accurate, for, as the gun was always laid for the line of fire, and no alteration was made in its direction during the firing of a particular group, a certain amount of deviation would be given to all the shots by the wind. Therefore, the closer the shots lay, the better was the shooting, without regard to the general deviation from the line of fire, which might be greater or less according to the direction and force of the wind.

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Table of Experiments.

3-Pounder Gun, 9 shots fired at an elevation of 3°, charge 7½ oz., February 22.

Range in yards.	Deviation from line of fire in yards.	
1552	⅓	Average longitudinal deviation, 11⅓ yards; average lateral deviation, ⅔ yd.; measured from the centre of 9 shots fired.
1568	2	
1573	⅓	
1575	⅔	
1577	⅓	
1588	1	
1589	0	
1593	0	
1607	⅓	

3-Pounder Gun, 10 shots, at an elevation of 10°, charge 7½ oz., February 23.

Range in yards.	Deviation from line of fire in yards.	
3865	9⅔	Average longitudinal deviation, 48 yards; average lateral deviation 9·7 yards from the centre of the group.
3888	10	
3871	13	
3913	12	
2831	13	
3816	12	
3717	11	
3850	8	
3763	1⅓	
3905	2⅓	

3-Pounder Gun, 11 shots, at 20° elevation, charge 8 ozs., Feby, 23.

Range in yards.	Deviation from line of fire in yards.	
6650	22 right	Average longitudinal deviation, 33 yards; average lateral deviation 4 yds.; taken from the centre of group.
6614	21 „	
6655	24 „	
6702	17 „	
6646	17 „	
6704	17 „	
6690	19 „	
6581	19 „	
6692	19 „	
6645	7 „	
6712	7 „	

3-Pounder Gun, 5 shots, at 35° elevation, charge 8½ oz., February 16.

Range in yards.	Deviation from line of fire in yards.	
9453	52 right	Average longitudinal deviation, 81 yards: average lateral deviation 19 yards from the centre of the group.
9503	72 „	
9611	89 „	
9645	31 „	
9688	35 „	

12-Pounder Gun, 10 shots, at 5° elevation, charge 1½ lb.

Range in yards.	Deviation from line of fire in yards.	
2354	2⅔ right	Average longitudinal deviation 16 yards: average lateral deviation from centre of group, 1 yard.
2352	2⅓ „	
2351	3 „	
2348	2 „	
2347	4 „	
2343	2⅓ „	
2337	⅓ left	
2334	2 right	
2304	5 „	
2288	2 „	

12-Pounder Gun, 4 shots, at 7° elevation, charge 1⅔ lb., February 21.

Range in yards.	Deviation from line of fire in yards.	
3098	0	Greatest difference in range, 29 yards: greatest difference in width, 1⅔ yard.
3078	⅓ left	
3107	1⅓ right	
3107	0	

80-Pounder Gun, 4 shots, at 7° elevation, charge 14 lb.

Range in yards.	Deviation from line of fire in yards.	
3482	6⅓ right	Greatest difference in range, 21 yards; greatest difference in width, 1⅔ yard.
3487	6⅓ „	
3498	6 „	
3503	4⅔ „	

If three out of the four shots be taken, the greatest difference in range is sixteen yards, while the greatest difference in width is only *one foot!* Calculating the mean of deviation on the Hythe system, it is only four inches, a precision about equal to that of the Whitworth rifle musket when shot under

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most favourable conditions at one-seventh of the range of the cannon—that is, at 500 yards. Stating the result in another way, three out of four of the shots would have struck in an area sixteen yards long, and only foot wide, at a range of about *two miles*, and would have gone through a target not a yard high and only one foot wide!

Armstrong and Whitworth Cannon.

To the Editor of the Times.

SIR,—The recent notices in *The Times* have induced the publication of an article in the French *Revue Europèenne* on "*Le Canon en* 1860," which is of sufficient importance to be transferred in substance to your columns. The value of the appreciation of cannon having an exceptionally long range must be left to competent military authorities; but its views on the subject generally are well worthy the attention of your readers. It says:—

"In the spring of 1859 the French army marched to Italy, having with them the small rifled cannon, the renown of which became in a few weeks so great in Europe. The result of long and mysterious study and experiment, the new arm, until then unknown to our artillery, was welcomed by them as an instrument of victory, and did not fail to justify all the hopes that had been conceived of it; but all had not yet been attained. Since the great battle of Solferino, where the French cannon played so conspicuous a part, inventions have been pouring in on every hand, which professedly leave in the back ground our remarkable arm.

"But do they, in fact, do so? An arm of this kind is not produced by chance. They who know that our cannon was the result of investigations the most searching and scientific, of experiments the most persevering, followed up day by day for nearly 10 years, will hesitate before they give full credence to the advantages asserted to have been so rapidly obtained in other countries. They, perchance, may be disposed

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to think that more than one of the military nations of the Continent who now loudly proclaim the superiority of their rifled cannon may one day regret having too hastily transformed their guns. It is during actual warfare that mistakes are dangerous.

"These so vaunted cannon, so easily invented, which are made from one end of Europe to the other, are yet to be put to the proof. They are mostly yet enveloped in mystery, and we cannot, therfore, examine them in detail; but we may be allowed to observe in general terms that their greater or less excellence in the practice ground, even admitting that it be established, is but of secondary importance as compared with efficiency, handiness, and durability on actual service.

"Free England, less reserved in her revelations, affords us a little more information. *The Times* undertakes to declare that success is complete and definitive on the other side of the Channel. This word 'definitive' is, perchance, a little hazardous in artillery affairs.

"We certainly have seen improvements in arms deemed theretofore incapable of improvement.

"It is not sufficient that an artillery arm be made in accordance only with theoretic notions, however apparently incontestable; other conditions must be fulfilled to avoid practical failure.

"The communications of *The Times*, how discreet soever—perhaps designedly so,—have been welcomed by the public with much interest. Many of its readers, unskilled in technical information, have read with wonder the accounts of the enormous distances at which the Armstrong and Whitworth cannon have struck an object of comparatively small dimensions. Had they been less unacquainted with the experiments made in France during several years, they would no doubt, have been less disposed to wonder.

"We certainly must not treat lightly the results obtained by our neighbours—results certainly remarkable, and which

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Miscellaneous.

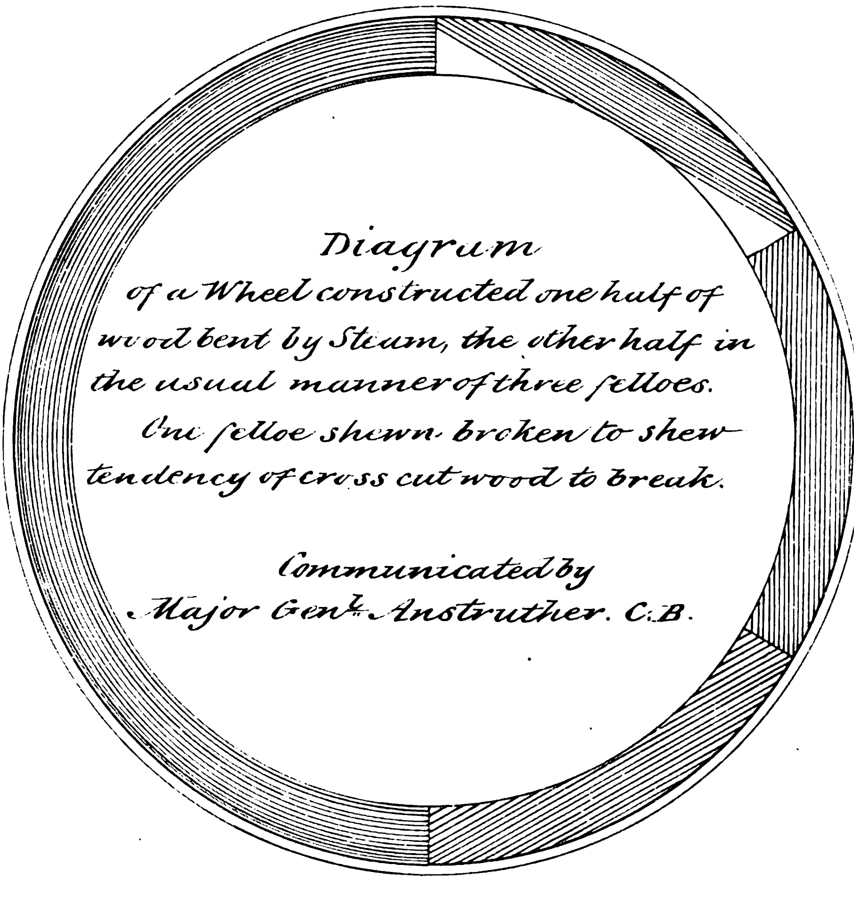

Diagram
of a Wheel constructed one half of wood bent by Steam, the other half in the usual manner of three felloes.
One felloe shewn broken to shew tendency of cross cut wood to break.

Communicated by
Major Genl. Anstruther. C.B.

MADRAS ARTY: DEPOT.

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do honour to their invention; but we must not, at the same time, forget to appreciate their worth.

"We admit as perfectly correct all the figures given by *The Times.* We will go further, and admit them as definitive bases, although only obtained from a limited number of experiments with new guns; but, admitting all this, we see no reason for apprehension. Let us endeavour to explain why; it is a simple matter of comparison.

"The new English cannon are not of bronze, as are most of ours, but of wrought iron. This is perhaps an advantage, since the chances of injury to the interior due to the ball are thus sensibly diminished; but we must also remember that in the French rifled cannon the ball does not touch the gun, being protected by zinc covering, a soft metal, which alone comes in contact with the rifling, and thus doing away with the principal objection to the use of bronze.

"Our neighbours have, it would appear, solved the difficult problum of breech-loading, but it still remains to be seen whether it may not in practice be open to serious objections, not only as regards the mechanism, but also as to other points.

"The Armstrong and Whitworth cannon are but recent inventions. The late experiments have certainly furnished remarkable results, but we have yet to learn what may occur after some service in the field. If certain rumours are to be credited, some doubts may exist as to their efficacy. What is said with regard to the results, cited by *The Times*, of Whitworth's six-pounders having lost at each shot about 120 feet in length of range?

"If this were to happen continually, what would become of the gun?

"Judging from the discussion in the House of Commons on the 5th March last, it would seem that the Armstrong and Whitworth guns are not very simple or handy on service. The Minister of War, although he stated that the

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Armstrong guns were superior both as to precision and destructive power, added that it would be necessary to send with them to China special workmen of Sir William Armstrong's.

" The practical value of the English cannon appears to us, as yet, open to question, while ours have been tested by service.

" Let us now consider the probale part which the new cannon may be called on to play, and in doing this we will confine ourselves to its consideration in siege service and in field service.

" As regards the first, the largest limit is open to conjecture. It appears without doubt that when besiegers and besieged are supplied with artillery having great precision and very long range, which is a problem now solved, the old system of attack and defence must be abandoned.

" Although skill and science may do much, yet it is probable that sieges will for the most part cease to be undertaken in warfare, and that either fortified places will be bombarded at great distances, or that the stake will be played out on the field of battle, leaving besieged places to be reduced by investment.

" As to field service the importance of the new artillery is more easy to determine, and as for this purpose it is necessary to enter into some technical details, we will endeavour to do so as simply and intelligibly as possible.

" We must first establish two points :—

" 1. What special properties field artillery should possess.

" 2. What conditions of firing should be satisfied.

" The most essential of all qualities to attain is, we may venture to affirm, a lightness and easiness of transport, which will enable the artillery to follow, so to speak, all the movements of the troops, This property, so conspicuously

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attached to our rifled cannon, largely contributed, as is well known, to the success of the campaign in Italy in 1859.

"The adoption of the 24lb. howitzer cannon of the Emperor realized in France, some years since a progress of the value of which our campaign in the Crimea enabled us to perform a correct judgment—that is, a unity of calibre. This is of much importance, since the projectiles are all alike capable of being used in all the guns.

"Another point is the facility of transport of ammunition. It is indispensible to have a provision of powder and projectiles necassary for all eventualities closely following the guns. The best solution of this problem is that which allows the greatest quantity to be taken with the least number of horses and ammunition waggons.

"Facility of transport and simplicity are, as it appears to us, the principal qualities of a field artillery, independently of considerations of firing. These qualities are possessed by our artillery, and in these we may be considered to be in advance of all our rivals, and it is in these, as we shall see, that rests true superiority.

"As to firing, certain conditions relate to range, and certain to precision, but with a close connexion with the two.

"The range of a gun depends partly on the inclination given to it; the more this is incresed, within certain limits and without any difference in the charge, the longer is the range, or, in other words, the greater the distance to which the projectile will be propelled. We will explain this more fully presently.

"If two guns be directed to the same point, that of greater precision is that the projectile of which arrives the nearest to the point in a right or straight line, and the least distance from such right line to the right hand or to the left.

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There is, therefore, precision in length or distance, and precision in direction.

"Precision in direction is of less importance on the field of battle. The point aimed at, whether infantry, cavalry, or artillery, almost always offers a front of a certain breadth, and whether the projectile travel a little to the right or left of a right line is of no great consequence. This precision of direction is the least difficult to effect.

"Precision in length or distance, or, in other words, so firing that the projectile shall attain the exact distance of the point aimed at, is the more difficult problem. On the field of battle one only of the elements of firing is variable, that is the elevation of the gun, since the charges being all prepared are all of the same weight. If the distance of the object were exactly known, it would be sufficient to give the gun the necessary elevation; but, unfortunately, this distance is almost always unknown. It cannot be measured, and the most skilful can only appreciate it by the eye, with large errors, frequently of many hundred yards in 2,000 or 3,000. 'At what distance are we?' is the first and general inquiry when the artillery commence their operations, and, as very rarely two opinions agree, the five opens at hazard. In a short time, it is true, they find the range by observation of the effects of fire; but the same uncertainty arises on every change of position, and a great many shots are consequently thrown away.

"Moreover, it is not easy to always observe the effects of the shot at great distances, besides which the smoke and other accidental causes frequently prevent observation. In every point of view the field of battle and the practice ground are very different places.

"Some compensation is certainly afforded by the chance effects of shots falling within or beyond the object aimed at.

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" While on this subject we must notice that it is most essential in all practicable cases to employ artillery with the least possible elevation, since the shots then plough as it were the earth, and destroy all in their course, and the advantage of this brings out the disadvantage of artillery with very long range.

" The observation of the effect of the firing, which is often the only means of rectifying the range, becomes more impracticable the more the distance is increased. Very difficult at 2,000 or 3,000 yards, it becomes immeasurably more so a little further. Of what practical use is it, then, to have an arm with an exceptional range of 4,000 yards, for instance? It is something to talk about, but that something is full of delusion. The distance is estimated (how? we would ask) from the enemy; the necessary elevation is given, and the gun is fired. What happens? An error in judging the distance is made, perhaps of a third. If the enemy is at 3,000 yards, the projectile passes over his head; if at 5,000, the ball falls 1,000 yards short. In such a mode of firing, one shot in a hundred may tell. Moreover, the elevation being necessarily great, the projectile falls to the earth like a thunderbolt, in a nearly vertical line, and at once buries itself without any ricochet. If it be a ball, it may by chance kill one man; if a shell, it may destroy two or three.

" Our soldiers at the Crimea nicknamed two of the Russian batteries, by way of derision, ' Bilboquét' and ' Gringalet,' as, being at a distance of some 3,000 or 4,000 yards, the elevation of the guns was so great that in several months, though firing night and day, they did not kill a single man; and this, be it remembered, though the exact distance was known. Contrast with this that at the Battle of Traktir one 24lb. shot killed 17 Russians formed in column, the gun being at a low elevation and the difference between firing at high elevation at great distance and with low elevation with a ploughing shot will readily be seen.

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"Cannon at long range cannot, therefore, be employed but in very exceptional cases, if ammunition be not thrown away. It will also follow that ordinarily the range in battle will be limited to 1,500 or 2,000 yards, and if for some special reason it be deemed necessary to adopt a longer range it must be limited to 3,000 yards, any further point being out of the reach of even good telescopes.

"It would be erroneous to suppose that by reason of these new cannon battle will be given hereafter at great distances. Attempts may doubtless be occasionally made to open a cannonade at long range, but the necessity of economizing ammunition, the obtaining certain and decisive results, and the utilizing cavalry and infantry, will lead probably to actual fighting at not much greater distances than heretofore. The rifled cannon, as effective as the old at short distances, will still have a superiority, as it will render more difficult the formation of cavalry and infantry, and can at greater distances throw disorder into an enemy's reserves, harass his retreat, &c.

"It was in this manner that our artillery was so effective in the last campaign, owing, however, much to its facility of being moved.

"All the nations of Europe are, and wisely, desirous of accomplishing the same progress, but the future will show it is a strange error to attempt it by an exaggerated length of range.

"It certainly is remarkable as an attainment of gunnery that Armstrong and Whitworth cannon should, at an angle of 35 degrees, throw a projectile some 10,000 yards; but it has no practical value, and, indeed, becomes a vice if done at the cost of the simplicity of the gun.

"What deserves more attention is uniformity in firing, which is more difficult of attainment.

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" For purposes of warfare the best artillery is such as is simple at the same time as efficient.

" We may be allowed to say that if the various foreign inventions tend to keep us on the alert they by no means are cause of apprehension, since at the present moment we will venture to say that our artillery has no superior in Europe, and for this assertion we have the the advantage of actual experience. Its simplity is extreme.

" The rifled 8lb. gun only weighs 600lbs., although in bronze it wears well in service. Four horses can move it rapidly up an incline apparently almost inaccessable.

" It may be used with good effect at considerable distances up to 9,000 yards, and even more if it were desirable. It throws an oblong projectile of 8lb., which produces all the effects necessary, not only as regards men and hoises, but also other obstacles.

" Its supply of ammunition is easy and not inconveniently weighty, since 4 horses can draw 100 charges.

" The projectile, althoug hollow, may be used as a ball; it may contain a sufficient quantity of powder to be used as a shell, for which purpose it is furnished with a metallic fuze adapted to various distances.

" Experiments are now being made to afford a means of judging distances by means of a small rocket, with a percussion apparatus, to be fired from these guns, so that the point at which the rocket arrives may be more accurately judged of.

" We cannot pass without observation two other rifled cannon we have for field service. The first is a mountain 8lb. gun, in which the same projectile is used as before mentioned, the gun being of extreme simplicity and so light (200lb.) as

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to be conveyed on the back of a mule, and capable of following infantry everywhere.

"Its range and precision of fire are equal to those of the 8-pounder already described. The second is the 24lb. howitzer cannon of the Emperor, rifled like the others, and capable of not only field, but siege service.

"The French artillery, then, has nothing to envy in the recent inventions of foreign countries."

If the writer's opinion on the inutility of exceptional range be well founded, it assuredly opens questions well worthy attention in England whether our improvements have been altogether in the right direction, and whether, having obtained a range sufficient for all practical purposes of warfare, other advantages in simplicity and weigh of the arm might not be attained by abandoning the elements of additional and useless range. It is too much the fashion in England to pooh-pooh every thing coming from a foreign source, but he must be of very dense or very prejudiced mind who does not admit, after even comparatively little investigation and experience, that the French are to be received as high authority in every thing connected with military matters, whether as relates to material, dicipline, or administration.

In France, in military affairs, at all events, will be found the "right man in the right place." The writer of the above article has come to his work with no prejudice and with no preconceived assumption of excellence and infallibility, and if he have asserted that the French artillery is still without a rival, he has done so in no vaunting or unbecoming terms, but has evidently arrived at the conclusion, after due investigation and comparison. There is nothing to shock the *amour propre* of the Englishman, but much worthy his attention.

T. J. T.

Paris, April 22.

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Examination of 12 Pdr. Howitzer shells (empty) by weight and gauge.—Communicated by Captain G. Carleton Adjutant Horse Brigade Madras Artillery.

Let R = radius in inches of shell to its exterior surface.
r = radius of hollow part in inches.
then will $2R$ = the whole diameter in inches.
and $2r$ = inner diameter in inches.

hence $(2R)^3 \times \cdot 5236$ will = content in cubic inches of solid sphere of same diameter as shell.

$(2r)^3 \times \cdot 5236$ will = content in cubic inches of a sphere of same diameter as hollow of shell.

$\therefore \{(2R)^3 - (2r)^3\} \cdot 5236$ will = content in cubic inches of shell as it is, no allowance being made for fuze hole, and the last content multiplied by ·263 will give the weight of shell in pounds and decimal fraction of a lb.; as the weight of one cubic inch of cast iron is ·263 of a pound avoirdupois.

Note.—·5236 is the $\frac{1}{6}$th of 3·1416 or p the surface.

$\{(2R)^3 - (2r)^3\} \cdot 5236$ = solidity.
$= (R^3 - r^3) \times 8 \times \cdot 5236.$
then since $6 \times \cdot 5236 = p, = 3 \cdot 1416.$
$\therefore 8 \times \cdot 5236 = \frac{4}{3} p$, 8 being the $\frac{4}{3}$ of 6
and $(R^3 - r^3)\ 8 \times \cdot 5236 = (R^3 - r^3)\ \frac{4}{3} p.$

	Inches.
1st. Shell, whole diameter or $2R$ measured...	4·43
Thickness of Shell	·75

$\therefore \cdot 75 \times 2 = 1 \cdot 50$ taken from 4·43 gives $2r$ inner diameter 2·93
Weight by Scales lbs. 8-0-12.

then $\{(2R)^3 - (2r)^3\} \times \cdot 5236$ = solidity of shell.
$\{(4 \cdot 43)^3 - (2 \cdot 93)^3\} \times \cdot 5236 =$ Ditto
or $86 \cdot 9383 - 25 \cdot 1537 = 61 \cdot 7846 \times \cdot 5236 = 32 \cdot 3504$ = solidity.

	lbs.	ozs.	drs.
32·3504 × ·263 = 8·5082 lbs =	8	8	2
Weight by Scales...	8	0	12
Calculated weight exceeds actual by	0	7	6

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Note.—$\cdot75 \times 2$ gives the sum of thickness of Shell at both sides.

	Inches.
2nd. Shell whole diameter or $2R =$	4·40
Thickness of Shell	·64
$\cdot64 \times 2 = 1\cdot28$ taken from 4·40 gives $2r$ inner diameter.	3·12

Weight by Scales 7 lbs. 3 ozs $1\frac{1}{2}$ drs.

$\{(2R)^3 - (2r)^3\}\ \cdot5236 =$ solidity of shell.

or $85\cdot1840 - 30\cdot3713 = 54\cdot8127 \times \cdot5236 = 28\cdot6999 =$ solidity.

	lbs.	ozs.	drs.
$28\cdot6999 \times \cdot263 = 7\cdot5481$ lbs. $=$	7	8	12
Weight by Scales...	7	3	1
Calculated weight exceeds actual by	0	5	11

	Inches.
3rd. Shell whole diameter or $2R =$	4·45
Thickness of Shell	·75
$\cdot75 \times 2 = 1\cdot50$ taken from 4·45 gives $2r$ inner diameter	2·95

Weight by Scales lbs. 8-2-2.

$\{(2R)^3 - (2r)^3\}\ \cdot5236 =$ solidity of Shell.

or $88\cdot1211 - 25\cdot6724 = 62\cdot4487 \times \cdot5236 = 32\cdot698 =$ solidity.

	lbs.	oxs.	drs.
$32\cdot698 \times \cdot263 = 8\cdot5995$ lbs, $=$	8	9	9
Weight by Scales	8	2	2
Calculated weight exceeds actual by	0	7	7

	Inches.
No. 4. Shell whole diameter or $2R =$	4·44
Thickness of Shell...	·75
$\cdot75 \times 2 = 1\cdot50$ taken from 4·44 gives $2r =$	2·94

Weight by Scales lbs. 8-1-12.

$\{(2R)^3 - (2r)^3\}\ \cdot5236 =$ solidity of shell.

or $87\cdot5284 - 25\cdot4122 = 62\cdot1162 \times \cdot5236 = 32\cdot5240 =$ solidity.

	lbs.	ozs.	drs.
$32\cdot5240 \times \cdot263 = 8\cdot5538$ lbs. $=$	8	8	13
Weight by Scales...	8	1	12
Calculated weight exceeds actual by	0	7	1

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	Inches.
No. 5. Shell whole diameter or $2R =$	4·44
Thickness of Shell	·72
$72 \times 2 = 1·44$ taken from 4·44 gives $2r =$	3·00

Weight by Scales lbs. 8-1-4.

$\{(2R)^3 - (2r)^3\}\ ·5236 =$ solidity of shell.

or $87·5284 - 27·0000 = 60·5284 \times ·5236 = 31·6927$

	lbs.	ozs.	drs.
$31·6927 \times ·263 = 8·3352$ lbs. $=$	8	5	5
Weight by Scales	8	1	4
Calculated weight exceeds actual by	0	4	1

	Inches.
No. 6. Shell whole diameter or $2R =$	4·45
Thickness of Shell	·73
$·73 \times 2 = 1·46$ taken from 4·45 gives $2r =$	2·99

Weight by Scales lbs. 8-1-12.

$\{(2R)^3 - (2r)^3\}\ ·5236 =$ solidity of shell.

or $88·1211 - 26·7308 = 61·3903 \times ·5236 = 32·1439 =$ solidity.

	lbs.	ozs.	drs.
$32·1439 \times ·263 = 8·4538$ lbs. $=$	8	7	4
Weight by Scales	8	1	12
Calculated weight exceeds actual by	0	5	8

In the above, the average weight of the 12 Pdr. Howitzer or $4\frac{3}{5}$ inch Shells is found to be

by actual experiment............lbs. 7 15 1

and by calculation............... „ 8 5 5 so the average excess of calculated weight over actual is, lbs. 0 6 4 and if we allow for fuze hole 1 oz. and 4 drs. weight of iron deficient, we get the excess of calculated weight over actual weight $=$ 5 ozs. or 8 lbs. 4 ozs. 1 dram.

In Straith's Memoir on Artillery the weight of 12-Pdr. Shell empty is given at lbs. 7-8-0; in Lefroy's Handbook for Field Service at lbs. 8-0-0 and in our Gunner's Assistant Tables..........lbs. 8-3-0.—Lefroy's Hand-

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book is probably correct for new Shells, and those measured and weighed by me seem with two exceptions new.

It will be seen from the above, that the difference in weight between 12-Pounder Howitzer Shells is at times as much as 15 ozs., as that between the 2nd and 3rd Shells or between the $\frac{1}{8}$th and $\frac{1}{9}$th the weight of shell when filled; allowing 5 ozs. as the bursting charge of powder and it is $\frac{3}{4}$ths. the weight of the service charge of powder, and when moreover we consider that the lesser weight is combined with greater windage, we need not be surprised at the inconsistency, more particularly in Ricochet of 12-Pounder Howitzer practice,* compared with that of the 6 or 9-Pounder Gun, more especially as the service charge, instead of being as in the gun proper rather more than $\frac{1}{4}$th of the weight of the shot, is from $\frac{1}{6}$th to nearly $\frac{1}{7}$th the weight of the shell when filled, and in comparing the comparative correctness in range of Light Field Guns and Howitzers, it is also to be considered that the proportionate difference between shot and shell is far less than between shell and shell;—$3\frac{1}{2}$ ozs. being more than the difference in weight found between any two 6lb. shot, or the difference between shot being about $\frac{1}{28}$, and the difference between shells being as high as $\frac{1}{8}$ to $\frac{1}{9}$ the total weight of projectile; the windage in the Howitzers, at least those attached to the C. Troop, it is to be observed is much less than that of the 6-pounder guns, and this again tends to bring the pieces on a par as to accuracy of fire;—without attempting any accurate calculation, it may from the foregoing be generally stated that greater correctness in range might be expected were the weights of the shells more equal or else the charges of powder somewhat more closely proportioned to those weights:—for instance, in our Gunner's

* Practice Returns at Bangalore show as much as 100 yards difference in range of 300 yards: i. e. charge being 4 oz. and elevation 6° in each round; some carried only 200 yards, others the required 300—again in a proposed range of 500 yards with 5° elevation and 7 ozs. charge, the actual range was from 400 to 450 yards; and lastly in a proposed range of 600 yards with 6° elevation and 7 ozs. charge, the actual range was from 510 to 554 yards.

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Assistant tables, the weight of 12-Pounder Howitzer Shell empty is stated to be 8lbs., 3 ozs. while by actual experiment some are found 1lb. more, that yet the service charge for all is the same; to proportion the charge would be practically impossible, but previously to their issue from Arsenals, if very old and light shot were marked in a way to be known as such, additional elevation could be given for them, and in like manner a gun the bore of which was enlarged to an extent approaching unserviceable or 3·7 inches in the 6-Pounder and 4·56 in the 12-Pounder Howitzer might be marked so as to be known, and some additional elevation could be given it.

To find the quantity of powder which will fill a Shell.

RULE.—1st. Find the content of hollow part by cubing its diameter and multiplying by ·5236.

2nd. Multiply this again by the specific gravity of the quantity of powder contained in one cubic inch, viz. ·534 oz.—thus for example, take the content of hollow of No. 6 Shell, that is $2r = 26{\cdot}7308 \times {\cdot}5236 = 13{\cdot}996$ cubic inches,—then $13{\cdot}996 \times {\cdot}534 = 7{\cdot}4738$ oz. or 7 ozs. 7 drams, which by actual experiment was found to be the exact quantity contained in the shell.

(Signed) G. CARLETON, Captain,
Adjutant M. H. A.

January 15*th*, 1859.

An Inquiry into the Nature and Principles of Rifled Cannon, and on their Effects upon the Attack and Defence of Fortresses.

The perfection to which the manufacture of rifled cannon has now been brought has created a new era in the art of warfare. The extraordinary length of range and accuracy of aim obtained by these guns, coupled with the corresponding improvement in rifled muskets, must entirely alter the principles on which the science of war has been founded, and neces-

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sitate new combinations and arrangements. This will tell with great effect upon movements in the field—upon the disposition of troops in line of battle—in their composition and manner of attack, and upon the peculiar features of the ground selected for a defensive position. Many of our most celebrated battle-fields would now be utterly worthless as strategical positions—the battle of Waterloo could not have been fought on the ground where it took place—Bonaparte could not have arranged his order of battle and taken up his position within a mile's distance of our batteries, and the whole tactics of that action must have been changed. Charges of heavy cavalry in an open plain, or attacks of infantry in masses or columns will become impossible; and when these new weapons are perfected, the manœuvres of large armies in a battle-field must be materially modified.

But, if these new guns will cause so great a change in field operations, the effect will be very much greater on the actions of a siege, where the artillery and riflemen play so important a part, and it is therefore the effects that will be produced on the attack and defence of fortresses by rifled ordnance that it is now proposed to consider.

But it will be well first to examine the capabilities of the ordnance now in use; and, as far as our knowledge of them extends, of the new rifled cannon of Armstrong and Whitworth. But little alterations had hitherto been made in Guns for the last 200 or 300 years. Experiments in gunnery were undertaken so long ago as 1586 in Germany; and in 1611, the gun called the Basilisk at Dover Castle, threw a 10-pound ball 1,200 yards with an elevation of 2°, and a charge of powder of 18lbs., and 2,000 yards with an elevation of 43°. In 1736 experiments were tried at Woolwich with 24-pounder guns, varying from 8 to 10½ feet in length, with charges of 12lbs. of powder, by which ranges of from 2,400 to 2,563 yards were obtained, the elevation of the guns being 7½°. In 1745 trials were made in France with

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cannon 10 feet in length, and charge of powder two-thirds weight of shot, at an elevation of 45°, with ranges as under—

	Range in yards.		Range in yards.
24-pounder	4,490	8-pounder	3,320
16 „	4,040	4 „	3,040
12 „	3.740		

Pieces of the same calibre, but somewhat shorter, had nearly the same ranges with charges of only one-third the weight of shot.

In 1739 other experiments were made in France with a 24-pounder at elevations from 4° to 40° as under—

Elevation.	Range in yards.	Elevation.	Range in yards.
40°	4,100	20°	3,480
35°	4,040	15°	3,350
30°	3,820	4°	1,640
28°	3,650		

Again, with a 24-pounder and 5° elevation, a range of 1,774 yards was obtained with 8lbs. of powder, and 2,020 yards with 9lbs. In 1750, at Turin, a 4-pounder gun gave a range of 2,375 yards at 14° elevation and 2lbs. of powder, and a 32-pounder gun ranged 3,172 yards with an elevation of 11¼° and 11½lbs. of powder. These data are sufficient to show that, with large charges of powder and high elevations, very long ranges were obtained upwards of 100 years ago, and the following table will show the average range of the guns now in use:—

	Length	P. B.	2°	5°	8°	12°	Weight. cwt.
8-inch shell gun	9	300	1,130	1,920	2,400	3,010	65
32-pounder gun	9·6	400	1,130	1,964	2.335	3,030	56
24 „	9·6	400	1,100	1,850	2,240	2,960	50
18 „	9·0	400	1,050	1,770	2,230	2.820	42
12 „	9·6	400	1,000	1,520	1,940	2,720	34
56 „	11·0		1,390	2,260	2,760	3,560	97

By which it will be seen that, as regards range, there has not been so much improvement, though, in accuracy of fire—in which the old guns were so sadly deficient—some

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advancement had been been made by using better refined metal, a more efficient and correct boring apparatus, and by casting the shot more accurately, but still at long ranges and high elevations the aim, even with our best guns, is very inaccurate.

Let us now turn to the ranges obtained, and practice made with the new rifled cannon—and first as regards Sir William Armstrong's guns, premising that our information regarding this weapon is very scant. The experiments that were tried before a select committee of officers, not having been made public, what knowledge we therefore possess of this gun has been through the public journals, and the most reliable, perhaps, is that obtained from Sir W. Armstrong himself at a dinner given to him in Newcastle in May last.

In the first place, it is stated that accuracy of aim, not length of range, has been the inventor's object in the construction of his gun, but that the extraordinary ranges obtained came as a natural consequence to the correctness of aim, consequent upon the perfection of workmanship of the gun.

At 600 yards an object the size of the muzzle of a gun may be struck at almost every shot.

At 3,000 yards a target of 9 feet square has been struck 5 times in 10 shots.

Two targets of 9 feet square were fired at from 1,500 yards with seven shells, and were struck in 596 places.

At 3,000 yards similar effects were produced. Shells may be thrown into a town or fortress at a range of more than 5 miles; when used as a shell it divides into 40 regular and 100 irregular pieces.

It combines the principle of the Shrapnell and percussion shell; that is, it may be made to explode either as it approaches the object or as it strikes it: it has burst on strik-

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ing a bag of shavings. It may be made to burst, like grape or canister, as it leaves the mouth of the gun, or to explode at very long or at very short distances, either by impact or by the action of the time fuze; and wherever it bursts it operates like grape shot.

It is composed of separate pieces, so completely bound together that it has been fired through a piece of oak 9 feet (9 inches ?) in thickness without sustaining fracture.

By means of an instrument constructed for maintaining a fire upon an object (a breach, for example) after darkness has set in, a distant object may be struck in a pitch dark night with the same accuracy as in broad daylight.

These experiments were made with a 32-pounder gun, weighing 20 Cwt., with a charge of 5 lbs. of powder; but guns to carry shot of 70lb. and 100lb. are under construction on the same principle.

The peculiarities of construction of Armstrong's rifled gun are now so well known that it is only necessary just to allude to them. The gun is made entirely of wrought iron, built up of separate pieces; it is loaded at the breech, through a screw working in the breech end of the piece, and pressing against a stopper, for the purpose of closing the bore; it has 44 rifled grooves, having one pitch in 10 feet, or making one complete twist round the inside of a gun at that length. The ball is made of cast-iron, thinly coated with lead, or with 2 bands of lead, and being of somewhat larger diameter than the bore of the gun, the lead is crushed into the rifle grooves, by means of which the necessary rotation is given, whilst all shake and windage are prevented.

Gunners who have used this gun declare that they would undertake never to miss a man at a mile distance, and at one of the foundries a strip of board is shown 22 by 9 inches, which was hit 3 times in 4 shots at 1,320 yards; and it is

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said that a target 10 feet square could be hit 90 times out of 100 by a good artilleryman at 4,000 yards, and the gun was fired 3,500 times, and as serviceable as at first.

The gun is sponged out after every shot through the hollow screw in the breech. The shot is conical, and about 2½ diameters in length.

Of the Whitworth gun, and of its powers, we have more detailed accounts, from the reports of the experiments at Southport in February last, and from Mr. Whitworth's letter to the "Times" of February 28. This gun is cast of homogeneous iron, cast solid and then bored. The bore is hexagonal in section, with the corners rounded off, the interior of the barrel being a hollow hexagonal spiral, the degree of twist varying with the diameter of the bore—being in the 80-pdr. one turn in 8ft. 4in.; in the 12-pounder, one turn in 5ft.; and in the 3-pounder one turn in 3 ft. 4 in.—the respective lengths of these guns being 9ft. 10in., 7ft. 9in., and 6ft., so that in the 3-pounder the shot makes nearly 2 complete revolutions before it leaves the gun; and it is from this gun that the most wonderful results have been obtained. The gun, then, is an open tube, rifled, if such a term can be applied to it, from mouth to breech; the breech or end of the tube is closed when the gun is loaded, by a cap screwed on externally, somewhat like the top of a telescope; this cap turns and works in an iron hoop, which is connected by a projection at the side of the breech by a huge joint, in which it swivels sideways; the touch-hole is fixed in the centre of the breech cap, at the back, and fired by a friction tube; the shot is first put into the gun through the breech, then the powder in a tin case fitting exactly into the hexagonal bore of the gun, having a lubricating wad attached to the fore-part of it (which at each discharge sponges out the gun, the tin powder-case remaining in the gun), the door or breech is then closed, when the cap screw fits on to its place, and three turns of the screw handle screw it on to the piece; it is mounted

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on a carriage admitting of the gun being fired at an elevation of 35°.

Mr. Whitworth says that his guns have not been made expressly with the view of obtaining great range—that is one of the advantages they possess, but it is not obtained at the sacrifice of others. They are adapted not only for firing solid shot, but also for hollow shot, which may be filled with molten iron, and for every description of shell, the capacity of which is easily increased by adding to its length; and as these guns are rifled throughout, and require no chamber, shells of any length (and consequently of proportionate weight) may be fired with any requisite charge of powder. They are so strong that, on a full charge of powder being fired with an immoveable plug in the gun, all the gases passed out through the touch-hole without injuring the gun, and 1,500 shots have been fired from the 3-pounder chiefly at high elevations without the gun exhibiting any injury or sign of wear.

The following is a table of ranges reduced from the data given in the "Times":—

Weight of Shot.	Elevation.	Charge.	Mean range in yards.	Greatest range in yards.	Mean deviation from line of fire.
3-Pdr.	35°	8 oz.	9,366	9,688	16 yards to right and left.
„	20°	8 oz.	6,960	7,073	4½ yards, and 1 shot 27 yards.
„	20°	7½ oz.	6,551	6,910	26 yds. to left, and 9 yds. to left.
„	10°	8 oz.	4,189	4,381	18 yards to right.
„	10°	7½ oz.	4,174	4,224	4½ yards to left.
„	3°	8 oz.	1,580	1,607	1¾ yards, 2 shot on the line.
12 „	10°	1¾ lbs.	4,027	4,120	12 yards to right.
„	5°	1¾ lbs.	2,322	2,350	1½ yards, 1 shot on the line.
„	2°	1¾ lbs.	1,254	1,280	½ yard right and left.
80 „	10°	12 lbs.	4,700	4,730	5½ yards to right.
„	7°	12 lbs.	3,490	3,503	4 yards.
„	5°	12 lbs.	2,566	2,550	3½ yards to right.
„	10°	10 lbs.	4,410	4,508	23½ yards to right.

Considering that these guns were laid and fired by Mr. Whitworth's mechanics, the accuracy obtained at the long

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ranges is something marvellous, when the deviation at long ranges from the unequal action of the air with shot fired from smooth-bored guns is considered—$4\frac{1}{2}$ yards in $4\frac{1}{2}$ miles—is truly wonderful; at 1,000 yards, with the 12-pounder with $1\frac{3}{4}$lbs. of powder, and 1°.28 elevation, 8 consecutive shots went through a target 4 feet square, 2 of them through the bull's-eye of 2 feet square.

Mr. Whitworth's 80lb. gun, which will carry shot of 100lbs. and it is said of even 200lbs. weighs 4 tons. The 12-pounder weighs 8 cwt., and the 3-pounder only 208lbs.

Comparing the results with the ordnance now in use we have:—

Elevation and Ranges.

Name of Gun.		Weight of Gun.	2°	3°	5°	10°	20°	35°	Charge.
Long	32-Pdr.	56 cwt.	1,130		1,964	2,682			10 lbs.
,,	24 ,,	50 cwt.	1,100		1,854	2,600			8 ,,
,,	12 ,,	34 cwt.	1,000		1,520	2,330			4 ,,
Field Battery	12 ,,	19 cwt.			1,400				4 ,,
Whitworth's	12 ,,	8 cwt.	1,254		2,322	4,027			$1\frac{3}{4}$,,
,,	3 ,,	208 lbs. 2 cwt.		1,580		4,189	6,960	9,366	8 ozs.
,,	80 ,,	80 cwt.			2,566	4,700			12 lbs.
Armstrong's	32 ,,	20 cwt.						9,130	6 ,,

It will be seen from this that at the low elevations, the range of these rifled cannon do not so much exceed that of the smooth bore gun, but it is at the higher elevation of 10° that the range is nearly double whilst the present guns cannot be elevated with safety on the carriages in general use, at a higher elevation than 12°, at which the ranges are only slightly more than at 10°; it is therefore from the power possessed by these rifled cannon, of throwing shot with great accuracy to extreme long ranges, that their effect upon the attack and defence of fortresses will be produced.

It has only been possible to make these comparisons with Mr. Whitworth's guns, but there is every reason to believe that those of Sir W. Armstrong are equally effective in

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range, and certainly—if not more so—in precision of aim. It need scarcely be mentioned that the shot used in these rifled cannon are of elongated form, somewhat similar to the Minié bullet, except that Mr. Whitworth's shot tapers slightly at *both* ends, thus rendering the balance of the shot more complete. No doubt, the total annihilation of all windage in these rifled guns, tends in a measure to increase their range, but it is most probable, that such increase is in a great measure due to the peculiar form of the shot, and to its rotatory motion through the air, as from the very slight excess of range, at *very low* elevations, it is probable that the point blank range of the rifled cannon would very little exceed that of the smooth bore, with the charges of powder with which each is respectively fired, and therefore that the initial velocity, or velocity at which the shot leaves the gun, may not be much greater than with the smooth bore; indeed it has been said that the Armstrong gun failed to penetrate the *Iron Plate* of the experimental mailed ship, and although Mr. Whitworth states, that the service cast iron 68-pdr. rifled by him, sent a shot right through the 4in. wrought iron plate as well as the ship's side at 450 yards, still this may have been chiefly owing to the peculiar *flat*-headed shot which he used, acting as a punch, and to the great weight, and consequent momentum of such a shot of the bore of a 68-pdr. gun, and not to a greatly increased initial velocity.

It is well known that a round shot cannot be projected from a smooth bore gun beyond a certain range, with any charge of powder, or with any elevation; this range with an extreme charge and at an angle of 45° being under 3000 yds. for a 24-pdr., and that this is owing to the resistance opposed to the shot by the air, which resistance Mr. Robins found to vary as the squares of the velocities of the shot, so long as those velocities did not exceed 1100ft. or 1200ft. per second, but that after that velocity, the resistance increased to such an extent as to neutralize the effect of increased charges of

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powder. Mr. Robins supposed this resistance to be at once treble what the squares of the comparative velocities would give: but although there appears to be no such sudden jump as that, still we find that with a 24lb. ball fired at an angle of 45° the actual range is only about $\frac{1}{7}$ part of what it would be in vacuo, with an initial velocity of 1200 feet per second; if the initial velocity is doubled, or 2400 feet per second, the resistance of the air is increased to 20 to 1, or nearly 3 times as much, and if the initial velocity is increased to 3200 feet per second, the resistance of the air is 39 times what it would be in vacuo, or more than 5 times what it is at the lower initial velocity; but as the resistance of the air operates throughout the range, the less the range, the less the resistance, so that at point blank, or at 500 or 600 yards the momentum of the round and elongated shot may be nearly equal, weight for weight, and the effects upon a wall or ship's side nearly the same.

If therefore the initial velocity of a 12-pdr. smooth bore gun, with a charge of 4lbs. of powder is nearly equal to that of a Whitworth or Armstrong rifled 12-pdr. gun with a charge of 1¾lbs. of powder, the extraordinary ranges obtained by the latter at high elevations, must be due to the peculiar shape of the shot, and to the rotatary motion round its long axis through the air, by which it bores its way through the resisting medium as it were, instead of being driven through it, as in the case of the round shot. "Spherical shot fired from smooth bore guns, acquire a whirling motion round their axes, by rubbing against the inside of their respective pieces," says Mr Robins, "and although this whirling motion is probably rendered more perfect and correct when projected from a rifle bore, still it is not so true as the revolving motion of an elongated ball round its long axis."

Again, to obtain very long ranges, it has been hitherto necessary to employ very large guns, because the resistance offered by the air to a shot is as its area of section, that is,

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as the *square* of its diameter, but the momentum, or power of the shot to penetrate the air, is as its solid content or weight, which is as the *cube* of its diameter, it follows that the ranges of shot of different sizes, the elevation being the same, and the charge of powder proportional, will be to each other as the cubes of their diameters to the squares of the same, hence, *ceteris paribus*, the larger the shot the longer the range; for instance, take a 9lb. and a 24lb. shot, and suppose them propelled with a velocity of 1,600 feet per second, the range of the 24-pdr. would be 2,264 yards, and that of the 9pdr. 1,745 yards (Sir H. Douglas's Naval Gunnery) or as 2·6 to 2. Now the diameter of a 24lb. shot is 5·82 inches, of the 9lb. shot 4·2, the squares of which are respectively 33·37 and 17·64, and the the cubes 197.1 and 74 the squares or area of resistance are as 2 to 1 nearly, and the cubes or momentum as 2·6 to 1, so the ranges would be to each other as 2·6 to 2, as above.

But with the elongated shot the case is quite different, for instance, take Mr. Whitworth's 12lb. shot, and 3lb. shot; here the momentum or weight is as 4 to 1, but the 12lb. shot has a diameter of $3\frac{1}{4}$in., and the 3lb. only $1\frac{1}{2}$in., hence the $3\frac{1}{4}^2$ or 10·56 is to $1\frac{1}{2}^2$ or 2·25 as 4·7 to 1; or the resistance of the air opposed to the large shot, in this case, is to its momentum or power of forcing its way through the air, as 4·7 to 4, and, therefore, the small shot ought, with proportional charges, to have the longer range, and this as regards the 12-pdr. and 3-pdr. we find to have been the case, the ranges of 10° elevation being respectively 4,120 and 4,380 yards, or as 4 to 4·25, at higher elevations, and with longer ranges the proportion would be still more.

If we test Mr. Whitworth's 80-pr. with a bore of 5 inches with his 3-pr. by the same rates, we have for his trial with a 90lb. shot the momentum as 30 to 1, the area of resistance as 5^2 to $1\frac{1}{2}^2$, or as 25 to 2·25 or 11·1 to 1, or the range of the 80-pr., as compared with the 3-pr., ought

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to be as 30 to 11·1, whereas they were only as 4,508yds. to 4,381 yds. thus showing that the 80-pr. is by no means so effective a gun for the size as the 3-pr; in the first place the proportional charge was not so much, that of the 3-pr. being 8oz. or $\frac{1}{6}$ weight of shot, that of the 90lb. shot 10lb. or $\frac{1}{9}$ weight of shot; and again, the extreme length of the 80-pr. is only 9ft. 10in., the actual length of rifle barrel through which the shot passes being little more than 7ft. 6in., while the length of the small 3-pr. is 6ft.; and what is probably of great importance, the pitch of the rifling is much greater in the 3-pr. than in the 80-pr., the one being one turn in 3ft. 4in. in a total length of 6feet; the other only one turn in 8ft. 4in. in a total length of 9ft. 10in., or the pitch of the 3-pr. is $2\frac{1}{2}$ times that of the 80-pr., causing the shot to revolve with so much the more rapidity. (The pitch in the Armstrong gun is 1 in 10feet.) Thus we see that in charge of powder, in length of barrel, and in quickness of rifling, the 80-pr. falls far short comparatively to the 3-pr., which is quite sufficient to account for its range not coming up to its proportional theoretical requirements.

The idea of using elongated shot is, however, not new, for in 1779, Dr. Hutton writes, "It would, therefore, be a great improvement in Artillery to make use of shot of a *long form*, or of heavier matter, for thus the momentum of a shot, when fired with the same weight of powder, would be increased with the square root of the weight of the shot, it would also be an improvement to reduce the windage, for, by so doing, $\frac{1}{3}$ or more of the quantity of powder might be saved, when the improvements in the two last articles both take place, about $\frac{1}{2}$ the quantity of powder might be saved, but this would be far exceeded by the nature of the guns, for then a small gun may be made to have the effect and execution of another 2 or 3 times its size in the present mode, by discharging a shot 2 or 3 times the weight of its natural ball or round shot, and thus a small ship might discharge shot as heavy as those of the greatest now made use of."

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Curious that it should have required nearly a century to carry these ideas into practical execution, but to do so necessitated a system of such beautiful and complicated machinery, such means of forging and working large masses of iron, as have only been brought into working order within the last few years; it has been by applying the nicety of the works of a chronometer to the ponderous mass of four ton iron gun that this feat has been accomplished, by a perfection of machinery which must be seen to be understood, in fact, it required the knowledge of details, the working skill, and all the appliances of the perfection of machinery to carry out the ideas roughly sketched by Dr. Hutton eighty years ago, and which he then declared to be the desideratum of gunnery.

Dr. Hutton knew that by increasing the weight of a shot in proportion to its area of section, and by reducing the windage of guns, greater ranges would be obtained from guns of the same calibre, but he does not appear to have calculated upon the effects upon the range, and the *accuracy* of aim, obtainable by giving a rotary motion on its longer axis to the elongated shot he proposed, thus at once taking the sting out of the hitherto unconquerable resistance of the air, to shots at high velocities, by boring through it as it were, and by the spiral motion round a long axis securing it from those deviations in its true line of flight, that shot *forced* through the air were subject to, and the perfect balancing of the shot by tapering both ends, in the Whitworth projectile, is a great improvement, due to the scientific and minute observation of that gentleman. Hence, the present long ranges and accuracy of fire are no miracles, no wonderful hap-hazard results, but the true deductions of scientific theory worked out by the utmost perfection of practical science and mechanical skill.

Another great advantage obtained by these guns is that in consequence of the small charges of powder, the carriages, especially for field purposes, will bear a much higher elevation than has hitherto been practicable with guns on ordinary

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carriages; instead of from 10° to 12° being the maximum of elevation, both Armstrong's and Whitworth's guns are fired with perfect ease at an elevation of 35°, thus greatly increasing the effective power of the gun.

Mr. Robins remarks that the depth to which a bullet penetrates in a solid substance, is a much more definite criterion of its comparative velocity, than the distance to which it ranges when fired at high elevations, as the penetrations vary in a much greater proportion than the velocities themselves.

Of the superority of the rifled cannon at *long ranges* there can be no doubt, whether this will be *equally* apparent at point blank distance, remains perhaps to be proved, but that a wonderful stride has been made in the art of propelling shot, no one can deny, or the effect this must have on modern warfare.

In the foregoing examination of the power and merit of the rifled cannon, we disclaim all intention of drawing any comparison between the merits of the Armstrong and Whitworth gun.

It has been necessary to enter into these details of the powers and peculiar properties of these rifled cannon, to show the points on which they chiefly differ from the guns in present use, so as to enable a correct judgment to be formed of the effects which they will produce on the attack and defence of fortresses, and which we will now proceed to consider.

First, then, as regards the effect upon the Attack. Sir John Jones says in his history of the sieges in Spain, that the artillery and engineer park were generally placed about 1800 yards to 2000 yards from the fortress, at this distance Armstrong's rifled cannon would strike any part of it every shot, and as they can fire live shells, or shells filled with molten iron, be made to explode on striking even a bag of shavings, be used as Shrapnell shells to separate into 150 pieces at any

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distance, the whole park would be set fire to and destroyed in a very few hours.

It is frequently necessary to construct lines of circumvallation against a relieving army, or contravallation against attacks by the garrison when numerous, those were usually made with great labour at a distance of from 2 to 3 miles from the place, out of gunshot, but now a camp pitched between lines at from 2 to 3 miles distance would be quite untenable, and to make such lines 4 or 5 miles distant would more than double the labour.

Again it has always been considered necessary to invest a place that is to be attacked, that is, not actually to surround it with troops, but so as to prevent the garrison from acting on the flanks of the approaches; and so as to cut off all means of communication with the country, for if this is not done, the defenders may receive reinforcements, and supplies of men and ammunition and stores, the ill effects of which were too painfully evinced at the recent siege of Sebastopol to require recapitulation here.

Now with the old 24-pr. gun carrying from 1 to 1½ miles, troops encamped beyond two miles from a fortress were pretty secure from molestation, to surround a place at a distance of two miles required a line of ground twelve miles in length to be watched and guarded from a relieving force, supposing that the enemy could advance to its relief from any quarter. But with guns carrying at five miles or more—And Sir W. Armstrong says that his guns would throw shells into a fortress (or camp) at a range of more than five miles—a length of ground of 30 if not 40 miles in circuit has to be covered and watched, if the investing troops are to be encamped, or even bivouacked out of effective range, and that every quarter requires to be guarded.

This of course supposes that the ground all round the fortress for such distances is so free from undulations, or hills,

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or ravines, as to afford no natural cover to the investing force, of which more will be said in its proper place.

In calculating, therefore, the strength of an army required to besiege and invest a fortress, it will be necessary greatly to increase the number of men, for it is clear that to watch or guard such an extent of country, except with an enormous army, the several corps must be so far separated from each other, as to render it difficult, if not impossible, for the several investing corps to march to the relief of the one attacked, which would subject them to be attacked and beaten one after the other by a relieving army.

The first parallel was usually opened at about 600 yards from the place; at the siege of Antwerp in 1832, the nearest point of the first parallel was only 325 yards, and the furtherest point 450 yards from the most advanced works of the citadel; at such distances not only would these rifled cannon hit a man at every shot, but the fire of the Enfield rifle would be equally effective at that distance, and the opening of the first parallel being carried on in the night would not save them at such a distance, as the rifled shot could be made to act as fireballs, by which every man would come under the fire of the rifle; and by Sir W. Armstrong's instrument, a direction once taken, the practice with his guns would be as correct in the darkest night as in daylight.

The first night the men just get themselves under cover, the parallel is completed in the day time; but, at 600 yards, this would be obviously impossible.

It has been said that the parapets of the parallels are only intended as screens to hide the men passing along them, and the besieged could not afford to waste their ammunition by firing; with the chance of hitting the spot where a man was passing but with the accuracy with which these rifled cannon carry at such a range every shot would strike within the space of one foot; and, as no counter-batteries can as yet have been erected, the fire would be so regular and rapid that, in a few minutes,

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a long gap would be cut through the flimsy parapet or screen in various places, which would effectually expose the men passing along the parallel to a concentrated fire from Enfield rifles, which would hit every man who attempted to pass or to repair the gaps; whilst the 12-pounder gun, which hits the bull's-eye at 1,000 yards, would knock over every gun as it was being dragged along to arm the enfilading batteries.

It was calculated that the enfilading batteries might be made to open in 36 hours from daylight in the morning after breaking ground, thus requiring more hours of day than of night work; but these batteries, at 600 yards from a fort, could not possibly be made under the fire of rifled cannon—every gabion would be knocked over as soon as placed; and, by Sir W. Armstrong's instrument, the position and direction of the battery once determined during the day, the practice against it would be as correct during the night, and render its construction, even under the cover of darkness, most dangerous and dilatory. The effects of this instrument will tell very severely upon the construction of the first approaches and batteries. Again, what would become of the guard of the trenches, which at such a distance from their supports, would require to be more than ordinarily numerous—even lying down on the ground would not save them at 600 yards, especially with the improvement which will doubtless take place in the range and efficiency of fire-balls, and the means of lighting up ground from a distance, thus exposing the guard of the trenches to every kind of missile and rifle shot. But, as the peripheries of concentric circles vary according to their radii, and as the first parallel must extend far enough at each extremity to enable the batteries in front of it to enfilade the faces of the bastions and ravelins of the fronts attacked, if the first parallel is retired, to say 1,200 yards; and, even at that distance, provided there is no natural cover, it would be a work of great danger—its length would be nearly doubled; and, as the whole extent of this parallel should be so far completed during the first night as to place

the working parties under cover, double the number of workmen will be required to achieve this; and, as the retirement of the first parallel would equally affect the extent of all the other approaches, and as there ought to be four reliefs of working parties, the total number of men required to prosecute the siege with vigour must be greatly increased for this purpose; and, as the guard of the trenches must extend all along the line of first "breaking ground," it follows that this doubling of the length of the first parallel will also require a corresponding increase in the guard of the trenches, and therefore in the number of the attacking forces.

In calculating, therefore, the number of men in proportion to the garrison required to carry on the duties of the siege, it will be necessary to take all these points into consideration: according to the best authorities, the besiegers ought to exceed the besieged by 5, or 8 to 1, say an average of 6 to 1, but this number only provided working parties for a first parallel of 600 yards from the place, but at 1,200 yards, not only the working parties must be greatly increased in number, on account of the two-fold length of the parallel, but the guard of the trenches must be proportionately more numerous, hence it will require the proportion of the attacking force to the garrison to greatly exceed the above numbers. It is true, that the greater the distance at which the first parallel is commenced, the less it will be exposed to sorties from the garrison, who, unless very numerous, could not venture so far from their works; but to prevent this it will be necessary that the cavalry placed on each flank of the parallel should be prepared to oppose all the cavalry in the garrison, particularly as they would be so far from their main support; as in the attack of Badajoz in 1812, forty or fifty of the enemy's garrison carried confusion into the very depôts of the artillery and engineers, and made prisoners of officers, at nearly 2,000 yards from the place. But with an open plain and no natural cover, bodies of cavalry would be terribly exposed to the fire of rifled cannon, throwing Shrap-

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nell, and shots equivalent to grape and canister at that distance under the light from the fire-balls, and yet they must be there, if the garrison have any cavalry.

As the engineer and artillery park must now be so much further removed from the place than formerly, and as it will be impossible to bring the stores required for the trenches, and the guns for arming the batteries across the open plain, exposed to the fire of rifled cannon, the labour of constructing these approaches from such a distance will be very greatly increased, and add to the delay of establishing the first parallel.

The great distance at which the engineer park must be established, and the distance of the camp, will add greatly to the fatigue of the troops in conveying stores, and ammunition, and guns, to the front, which will be still further increased as the siege advances, as also the very great distance which the reliefs of the working parties and guards of the trenches will have to march, added to the labour and fatigue of carrying the wounded to the hospitals in the rear.

Another point to be considered is the thickness which it will be necessary to make the parapets of the batteries to resist the momentum and accuracy of fire of the rifled cannon. In the first place, although the use of very heavy shot must be limited to a certain extent, as regards the attacking force, by the labour and difficulty of its carriage in the field, this will not affect the use of it by the garrison, who will thus be able to throw shot of such weight, that the construction of the first or enfilading batteries, will become a very dangerous and difficult operation. Now the superiority of the rifled cannon over the old guns increases as the range increases, and whilst 600 yards was nearly ½ of the accurate and effective range of a 24-pounder, 1,200 yards will not be above ⅓ the accurate and effective range of a rifted cannon, or the distance at which the penetration may be considered equal; and as the garrison will be able to use from 32-pounder to 60-pounder

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guns, or even larger calibres, for the destruction of these batteries, the penetration of such a weight of metal with a velocity due to only ⅓ of their range will be very great, and require an increased thickness of parapet—thus adding greatly to the labour and difficulty of their construction.

If therefore it is necessary to increase the thickness of the parapets, the time formerly allowed for their completion must be extended, as only a certain number of men can work at a battery at the same time, and be the occasion of great loss and delay.

The second parallel under former circumstances, was constructed at about 300 yards from the place, in somewhat the same manner as the first parallel, but if this is removed to even 600 yards, it will be more under fire of all kinds of missiles from the rifled cannon, as well as from the Enfield rifle, than it was formerly at 300 yards, and the batteries in front would be proportionally more difficult of construction.

Hitherto, when within 300 yards of the fortress, and exposed to a fire of grape and musketry, it was necessary to resort to the sap, to carry on the approaches, and if the fire from the place was very animated, even the double sap became requisite, but now, the whole distance between the second parallel and the fortress will be under such a concentration of deadly fire of all descriptions, and, as an Engineer Officer has truly said, "the fire of the lightest piece of artillery at the head of a sap will effectually stop its progress during day-light." It will be absolutely necessary, either to silence the guns of the garrison, or completely to divert their attention, before it will be possible to carry on the near approaches, even by sapping.

The question will then resolve itself into the power of the besiegers to silence the fire of the garrison; the fact of a besieging force occupying concentric circles round a centre, has always given it the preponderance of fire, and has rendered the duration of the siege a mere matter of time,

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and when once the besiegers have been enabled to erect their counter and enfilading batteries, so as to overpower the fire of the place, it is possible that the scales may be turned, and that the established principle must in the end prevail.

But it will be in first investing a fortress, in constructing if necessary, lines of circumvallation and contravallation, in first breaking ground and establishing the first parallel and its batteries, and in the great distance from which all supplies—guns, ammunition, &c.—will have to be brought, and the fatigue and labour thus entailed, as well as the distance all relief of working parties and guards of the trenches will have to march, that the advantage will be on the side of the besieged; and it may now truly be said, that all the energy, all the resources, all the means of obstruction possible, should be brought to bear by the garrison, to harass, delay, or prevent the enemy's making his first lodgement. The construction of the first parallel should not be looked upon as a matter of course, or that the real business of the siege does not commence till the 2nd or 3rd parallels or breaching batteries are marked out; the object of the besieged should be to harrass the enemy in every way in his power, to make him keep his camp and engineer park at as great a distance as possible, by the free use of fire-balls and improved means of lighting up the ground, and concentrated fire of rifle cannon, upon the spot selected for breaking ground, to delay and cause him much loss in first getting under cover, and by all the various appliances of the Armstrong gun and its projectiles, to cause the formation of the first parallel and its batteries, to be a most hazardous and difficult operation—for that once accomplished, the old game begins.

It will now become more than ever necessary to improve the means of lighting up, if possible, the ground on which the first parallel is being constructed; this was not of so much importance when these works were carried on beyond musketry range, or that of grape and canister; but with the

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power these rifled cannon possess of throwing Shrapnell, and the equivalents of grape and canister, to very long distances, and the vastly improved power of the rifled musket, these works can only be commenced under the cover of the darkness of night. It should, therefore, be the aim of the garrison to use every means to render this darkness of no avail, so as either to oblige the enemy to commence his approaches at such a distance as greatly to increase his labour, or to subject him whilst so employed to be totally exposed to the concentrated fire of every description of missile.

The danger and difficulty of reconnoitring, and of fixing with accuracy the line of the parallel and the position of the different bodies of workmen will be very great, and yet, unless this is done—and well and correctly done—mistakes, confusion, and failure are sure to occur; and to obtain correct positions for the enfilading and counter-batteries, on which the power of silencing the fire of the garrison depends, will be a work of much difficulty and danger.

It is probable that the number of guns necessary for the attack of a fortress will require to be very much increased, for as these rifled cannon require so very few men to work them, the garrison will be able to man so many more of them, and being so light in proportion to their calibre, they can be easily moved from one part of the works to another, by which means a mass of direct fire on the approaches might be obtained from various points, which it would require a very numerous artillery to silence.

Sufficient has now been said to show how very much these rifled cannon will add to the labour, fatigue, danger, and time of the attack, so we will now proceed to notice some of the difficulties which they will oppose to the Defence of fortresses.

In the first place it is a rule when a besieging force advances to the attack of a place, the first thing to be done is to level

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all obstructions, and to clear the ground on all accessible sides to a distance of 1,000 to 1,200 yards. To clear the ground for only such a distance as this would entirely neutralize all the advantages to be derived by the garrison by the use of rifled cannon, the ground must be cleared to at least 2 or 3 miles to bring into action all the advantages of these weapons. This evidently could not be done with many of the existing fortresses, and would at all times be a work of great labour; but it must be done; for, if cover is left, under, or behind which, the enemy could establish his camp and engineer park, and make his first approaches, or make cover for his marksmen within rifle range, or establish batteries, to dismount the guns of the place, the whole balance will be destroyed, and the attack will at once obtain the ascendancy.

How this will tell upon all existing fortresses we will not stop to enquire; but in the construction of all works henceforth, this must be considered a *sine-qua-non;* unless an open space, exposed to the fire of artillery, for a distance of from 2 to 3 miles can be secured, the advantage of the rifled guns to the besieged will be neutralized, and these new weapons will be on the side of the attacked.

It is true, that should there be any commanding position near a fortress, which from its natural character could be made inaccessible, or most difficult of capture, when protected by the fire of the place, then the occupation of such a position by a strong work, commanding the fortress even at a long range, and looking down upon the ground in front of it, would most materially add to the strength of the place, as from the large extent of ground it would cover, it would drive the enemy to such a distance from the place as to render a regular attack by approaches almost impracticable, and necessitate the capture of the position previous to setting down before the main works, or of attacking the place from some other side.

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But undulating ground, villages, small eminences, and hollows, &c., from which the besieged could be easily driven by a besieging force, and occupied by the enemy, will now become points of great weakness to a fortress, and it should be considered as a maxim, that no advanced position should be occupied by defensive works unless such works are very strong, or the position most difficult of access, for if of a nature to be easily taken by the enemy directing his whole strength upon them, and then making them the base, as it were, of his attack, it is probable that the place would *fall* an easy conquest if commanded by such a position in the hands of the enemy.

These rules always applied to outworks within easy cannon or musketry range, but they apply with double force now the powers of both these arms are so multiplied, that the *fire* of the rifle is so deadly at such distances, and that breaches could be made in exposed revetments from such long ranges. This, then, is a point that must be seriously considered in selecting the sites of future fortresses.

This brings us naturally to the subject of *Defilement*, which will be more necessary and more difficult of attainment than ever. The nature and effects of the *command* of a place have been most ably discussed by the late Sir John Jones, in his "Sieges of Spain," from which we must shortly quote, as bearing so directly on the subject. "The most prominent disadvantages," he says, "of being commanded are, that the defenders and the interior of the place are seen by the enemy, and that the escarps may be breached lower down than from the plain." On which Sir J. Jones remarks, "Considered abstractedly, to be seen is rather an inconvenience than a positive ill; and as the point blank range of a 24-pr. is under 600 yards, and as it will not batter with good effect at a greater distance than 800 or 1,000 yards, it would seem that all command beyond the latter distance is nearly harmless, except from the inconvenience it occasions of being seen."

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